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Experimental Animal Models of Bruises in Forensic Medicine – A Review

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Summary

Estimating bruise age is a central issue in both human and veterinary forensic medicine. Since 1957 experimental animal models have been developed in order to find an objective way for dating bruises. Experimental bruises have been inflicted in cows, sheep, pigs, rabbits, chickens, mice and rats, and in young and mature animals of both sexes. Although a number of analyses have addressed the timing of bruises, a consensus regarding an optimal method for determining bruise age has not been achieved. In this paper, a review of experimental animal models of bruises is presented.

Introduction

A bruise is defined as an extravasation of erythrocytes into the subcutaneous tissue. It is caused by impact from a blunt object which leaves the skin surface intact but results in the walls of veins and small arteries being torn (*Hamdy et al., 1957a; Langlois & Gresham, 1991; Saukko & Knight, 2004*). Experimental animal models of bruises have been developed for more than half a century in order to find an objective way for dating bruises in humans and animals (*Hamdy et al., 1957a,b,c*).

The objective of the present paper is to review animal model reports on bruises with a forensic aspect and written in English. Experimental models of bruises in skin and muscle with a specific relation to forensic evaluation and dating are included. Moreover, only models in which bruises were applied by blunt trauma leaving the skin surface intact are included.

Thirteen studies on bruises fulfil the inclusion criteria and are listed in Table 1. This table summarises the design of the studies with regard to the species used, the age or weight of the animals, the number of animals, and the time from the bruises being inflicted until the animals were sacrificed. In Tables 2-6 the results from each of the 13 studies are summarized.

Induction of blunt trauma

The details of the methods by which bruises have been inflicted vary considerably. In the report of Hamdy *et al.* (*1957a*), bruises were inflicted using a seven pound sledge hammer with two blows from 3 feet in 0.5 sec. Hamdy *et al.* (*1957b*) stated that animals were bruised using approximately the same force as described by Hamdy *et al.* (*1957a*). In later experiments, Hamdy *et al.* (*1960, 1961a,b*) described that the bruises were inflicted by an instrument to produce a standardized and reproducible bruise. This instrument was also used several years later by Northcutt *et al.* (*2000*). Methods to inflict bruises are described in more details since 1978. In some reports, bruises were inflicted by dropping an object through a tube onto the skin of the animals (*Thornton & Jolly, 1986; Sun et al., 2010; Du et al., 2013*). Other methods included a modified captive bolt pistol (*McCausland & Dougherty, 1978*) and a device compressing the skin (*Takamiya et al., 2005*). Randeberg *et al.*, (*2007*) used a pendulum device and a paintball released by pressurized air with an average

force of 500 and 600 N to create bruises. In Mao *et al.* (*2011*) an iron hammer was used to induce trauma from a height of 10 cm. Most importantly, in these more recent experiments, the methods used inflicted reproducible bruises, which made it possible to compare bruises of various ages at least within each study.

Anaesthesia and analgesia

From 1957 to 1986 no anaesthetic or analgesic treatment of the animals is specified in the experiments performed. In later studies, chickens were anesthetized with ketamine and mice and rats with ether or isoflurane inhalation anaesthesia prior to inflicting the bruises (*Northcutt et al., 2000; Takamiya et al., 2005; Sun et al., 2010; Mao et al., 2011; Du et al., 2013*). However, no analgesic treatment after infliction of bruises was specified. Northcutt *et al.* (*2000*) anesthetized broilers using an intramuscular injection of ketamine prior to infliction of bruises, and the animals were sacrificed 0 h, 1 h, 6 h, 12 h and 24 h post injury. However, according to Lierz and Korbel, (*2012*) the analgesic potency of ketamine is insufficient for surgical and painful procedures in birds. Takamiya *et al.* (*2005*), Sun *et al.* (*2010*), Mao *et al.* (*2011*) and Du *et al.* (*2013*) anesthetized mice and rats with ether or isoflurane prior to infliction of bruises. None of these anaesthetics possess an analgesic effect and no additional treatment was specified in the studies. It is unclear if inflicted bruises caused pain, but it has to be considered. As animal experiments require monitoring for pain, analgesic treatment could have been given although not described in these reports. Randeberg *et al.* (*2007*) inflicted bruises in female pigs under general anaesthesia maintained by inhalation of isoflurane and continuous infusion of fentanyl and midazolam. While still in anaesthesia, the pigs were euthanized by giving an overdose pentobarbital.

Species, gender, age of the animal and number of bruises

Experimental bruises have been inflicted in cows, sheep, pigs, rabbits, chickens, mice and rats, in young and mature animals, as well as in animals of both sexes (Table 1).

Hamdy *et al.* (*1957c*) found that inflicting three bruises in one rabbit resulted in a quicker healing of the third bruise compared to the healing of a single bruise in another rabbit. In the same study, it was found that bruises in young rabbits healed quicker compared to bruises in adults. This was later also confirmed to be true for chickens (*Hamdy et al., 1961b*).

Information regarding the healing of bruises depending on animal species is not available. However, in studies of wound healing, differences have been found between species. Mice, rats, rabbits and hamsters have a subcutaneous panniculus carnosus muscle which takes part in wound healing by contraction and formation of collagen (*Gottrup et al.*,

Table 1. Design of animal bruise models

Species/gender	Age/weight	Number of animals*	Age of bruises	Reference
Cattle	N	55	15 min, 2, 3, 4, 5, 6, 7, 8 and 9 days.	Hamdy *et al.*, 1957a
Cattle	N	Several	15 min, 15 h, 24 h, 40 h and 2.5, 3, 4, 5, 7 and 8 days.	Hamdy *et al.*, 1957b
Rabbits Cattle Sheep Pigs, male	2-8 months N N N	>146 N N N	Various.	Hamdy *et al.*, 1957c
Chickens	8-10 weeks	N	2 min, 12 h, 24 h, 36 h and 2, 3, 4 and 5 days.	Hamdy *et al.*, 1960, 1961a
Chickens	4-30 weeks	1024	Various.	Hamdy *et al.*,1961b
Calves, female and male Lambs, female and castrates	10-14 days 5-6 months	20 20	8, 24 and 48 h and instantly before slaughter.	McCausland & Dougherty, 1978
Lambs, male-castrated	3-12 months	50	1, 2, 4, 6, 8, 12, 16, 20, 24, 30, 36, 60 and 72 h.	Thornton & Jolly, 1986
Chickens, male	41 days	36	0, 1, 6, 12 or 24 h.	Northcutt *et al.*, 2000
Mice, male	6 weeks	35	1, 2, 8, 24, 72, 144 or 240 h.	Takamiya *et al.*, 2005
Pigs, female	24-40 kg	4	Up to 5 h.	Randeberg *et al.*, 2007
Sprague-Dawley rats, male	10-12 weeks	48	0.5, 1, 6, 12, 18, 24, 30, and 36 h.	Sun *et al.*, 2010
Sprague-Dawley rats	140-170 g	24	1, 3 and 6 h.	Mao *et al.*,2011
Sprague-Dawley rats, male	10-12 weeks	72	4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44 and 48 h.	Du *et al.*, 2013

* Number of animals in which blunt trauma was inflicted (does not include control animals)

N = No information available

2000). In addition, wound healing was observed to occur more rapidly in ponies compared to horses (*Wilmink et al., 1999a,b*). Bohling *et al.* (*2004*) compared wound healing in dogs and cats and found the formation of granulation tissue and re-epithelialisation to be significantly quicker in dogs compared to cats. However, Hamdy *et al.* (*1957c*) compared the rate of healing of bruises in different animal species and found no differences.

Mass and speed

Differences in time responses have been observed in bruises inflicted by objects of varying mass and speed (*Randeberg et al., 2007*). Bruises inflicted by heavy objects with low speed were characterized by deep haemorrhage in the muscle tissue underlying the site of impact. By contrast, bruises inflicted by low mass and high speed (paintball) were instantly visible on the skin surface but caused no muscular hematomas. Previously, Hamdy *et al.* (*1961b*) also found that the extent and severity of tissue damage was related to the force applied in chickens. However, in that study the sequence of visible and chemical changes was the same regardless of the force applied.

Anatomical location

In the different animal models, bruises have been inflicted at various anatomical locations. In calves, lambs and sheep, bruises were inflicted on the limbs (*McCausland & Dougherty, 1978; Thornton & Jolly, 1986*). In chickens, bruises have been inflicted on the breast, thighs and wings (*Hamdy et al., 1960, 1961a,b; Northcutt et al., 2000*). In rodents, bruises have been inflicted on the back and on the limbs (*Takamiya et al., 2005; Sun et al., 2010; Mao et al., 2011; Du et al., 2013*). Randeberg *et al.* (*2007*) inflicted bruises on the shoulder and in the hip region of pigs. In some reports, the location of the bruises was not stated or described as "various areas" (*Hamdy et al., 1957a,b,c).*

The anatomical location of a bruise has been demonstrated to influence the severity (*Hamdy et al., 1961b*) and the colour intensity of the lesion (*Northcutt et al., 2000*). Notably, more tissue damage was observed in bruises inflicted close to bones (*Hamdy et al., 1961b; Randeberg et al., 2007*).

Analysis

The methods used to evaluate the age of experimental bruises were gross and histological examination, enzyme histochemistry, Real-Time quantitative PCR, in situ hybridization, reflection spectroscopy, ultrasound, electric impedance spectroscopy, colour measurements and various chemical and physical analyses (Tables 2-6). Some methods were only used in single studies (Table 6).

Estimating the age of bruises

Estimating the age of bruises is a central issue in both human and veterinary forensic investigations, and a greater knowledge of the changes in bruises over time is needed (*Langlois, 2007; Byard et al., 2008; Barington & Jensen, 2013*).

From the review of animal models of bruises it is apparent that extrapolating the results from one species to another, including comparing animals to humans, is not always possible. In addition to differences with regard to animal species, the method by which the trauma was inflicted, the time from trauma to sacrificing the animal, the anaesthetic protocol and the methods for analysing lesions make a direct comparison between the results of the 13 studies difficult (Tables 1-6). Also the anatomical location, the number of bruises and the age of the animals are factors influencing the inflammatory changes in bruises (Table 2).

Various methods have been used to analyse the age of experimental bruises (Tables 2-6). Colour changes in skin after inflicting a bruise were described in five studies (Table 2) (*Hamdy et al., 1957a, 1960, 1961a; McCausland & Dougherty, 1978; Northcutt et al., 2000; Randeberg et al., 2007*). In all of these models, bruises initially appeared red, then continued through shades of purple, green and yellow due to breakdown of haemoglobin into bilirubin and biliverdin. Although the pattern of changes in colour is quite similar, the timing of the changes differs which makes visual assessment of colour an unsuitable method for estimating the age of bruises. Similarly, visual assessment of the age of bruises in humans is also regarded as unreliable (*Maguire et al., 2004; Grossman et al., 2011*).

Histological evaluation of bruises was described in five reports (Table 3). Haemorrhage was found in the subcutaneous tissue and the underlying muscle by McCausland & Dougherty (*1978*) and Northcutt *et al.* (*2000*). Randeberg *et al.* (*2007*) found that the location of haemorrhage depended on the mass and speed of the object inflicting the trauma.

With regards to infiltration of inflammatory cells, McCausland & Dougherty (*1978*), Takamiya *et al.* (*2005*) and Randeberg *et al.* (*2007*) described the earliest presence of neutrophils after 8, 1 and 4.5 h, respectively. Takamiya *et al.* (*2005*) and McCausland and Dougherty (*1978*) described moderate and

Table 2. Gross findings in animal bruise models

Species	Gross findings	Reference
Cattle	15 min: Dark red swelling and red fluid. 2 days: Dark red fluid. 3 days: Light green-purple swelling, brown red fluid. 4 days: Yellow orange fluid, yellow-green-purple skin. 5 days: Orange skin. 6 days: Slight orange skin, yellow fluid. 7-9 days: Normal skin.	Hamdy *et al.*, 1957a
Rabbits Cattle Pigs Sheep	Multiple bruises: In rabbits with 1, 2 or 3 bruises, the most recent bruise healed in 7.9, 6.6 and 5.9 days, respectively. Species: No species differences regarding the gross changes of bruises during healing (cattle, pigs, sheep and rabbits). Effect of force: Bruises inflicted by using varying mass and velocity had the same sequence of visible changes during healing (cattle, rabbits). Location: The extent of tissue damage differed depending on the location of infliction of a bruise. The sequence of visible changes during healing was the same (cattle, rabbits).	Hamdy *et al.*, 1957c
Chickens	2 min: Red swollen skin, red fluid. 12 h: Red-purple skin and fluid. 24 h: Light green-purple skin, brown fluid. 36 h: Yellow-green-purple skin, yellow-orange fluid. 2 days: Yellow-green or dark green skin, orange or dark green-yellow fluid. 3 days: Yellow orange or almost normal skin, yellow fluid. 4-5 days: Normal skin colour.	Hamdy *et al.*, 1960, 1961a
Chickens	Effect of force: Extent and severity of tissue damage was related to the force applied. Sequence of visible or chemical changes was consistent regardless of force applied. Location: More tissue damage was encountered in bruises inflicted close to bones. Effect of age: Chickens aged 4-6 weeks healed significantly faster (3.6 days) compared to broilers (age 8-10 weeks; healing time 4.4 days) and old birds (age 28-30 weeks; healing time 5.2 days). Multiple bruises: In chickens with 1, 2 or 3 bruises, the most recent bruise healed in 4.4, 3.8 and 3.2 days, respectively. Temperature: Sudden decreases in environmental temperature (45°F), decreased susceptibility to bruising and decreased healing rate compared to birds subject to higher temperature (86°F) which bruised easily but healed at a faster rate.	Hamdy *et al.*, 1961b
Calves Lambs	0 h: A red area in the subcutis and muscle tissue beneath the impact site. 8 and 24 h: The red area was wider and deeper and clear fluid was seen in the muscle septa and subcutis. 48 h: Calves: The red area was small and dry. Muscle tissue appeared yellowish red. Lambs: As for bruises aged 8 or 24 h, except that the septal and subcutaneous fluid was yellow/green.	McCausland & Dougherty, 1978
Chickens	The colour of the tissue initially appeared red, then continuing through shades of purple, green and yellow. At 24 h post-injury the bruises appeared green.	Northcutt *et al.*, 2000
Pigs	Low speed injuries: A wheal and flare reaction developed within 20-30 sec and disappeared within minutes. High speed injuries: A central whitening of the skin surrounded by an erythema. A haemorrhage in the upper skin layers was observed within 1-2 min. This was followed by red, blue and purple rings forming simultaneously with different radii around the central zone.	Randeberg *et al.*, 2007

Table 3. Histological findings in animal bruise models

Species	Histological findings	Reference
Calves Lambs	0 h: Moderate haemorrhage in the subcutis and muscle tissue. Few neutrophils. Fibrin was occasionally seen. 8 h: Extensive haemorrhage. Fibrin strands. Many neutrophils and few macrophages present. 24 h: Equal amounts of macrophages (some of them containing haemosiderin) and neutrophils. The amount of haemorrhage and fibrin was similar to 8 h lesions. 48 h: Dominated by macrophages often containing haemosiderin. In the subcutis and muscle tissue endothelial cells with a plumb morphology were present.	McCausland & Dougherty, 1978
Sheep	Degeneration, inflammation and repair in muscle and adipose tissue were scored on a semi-quantitative scale. A statistically significant ($P<0.05$) relationship between scores and the age of a bruise was found for neutrophil and macrophage exudates, fibroplasia, haemosiderin in macrophages and endothelial cell hypertrophy. Relative probabilities of observing particular combinations of scores in individual bruises were calculated by application of a Bayesian probability model. The model was able to age bruises as being 1-20 h or 24-72 h old.	Thornton & Jolly, 1986
Chickens	Progressive muscle degeneration was observed in bruises on the thighs but not on the breast and wings. Maximum oedema was found in bruises 6 h of age. Red blood cells in the subcutis and muscle tissue increased from 1 to 12 h post-injury.	Northcutt *et al.*, 2000
Mice	1 h: Slight infiltration of neutrophils in the subcutis and lower third of the dermis. 3 h: Slight infiltration of neutrophils and macrophages in the subcutis and lower half of the dermis. 8 h: Moderate infiltration of neutrophils and macrophages in the subcutis and lower half of the dermis. 24 h: Moderate infiltration of neutrophils in all layers. Moderate infiltration of macrophages in the subcutis and lower half of the dermis. 72 h: Strong infiltration of neutrophils, moderate infiltration of macrophages and slight infiltration of lymphocytes in all layers. 144 h: Slight infiltration of neutrophils and moderate infiltration of macrophages and lymphocytes in all layers. 240 h: Slight infiltration of neutrophils and macrophages, and moderate infiltration of lymphocytes in all layers.	Takamiya *et al.*, 2005
Pigs	Low speed injuries: Deep haemorrhages were found in the muscle tissue beneath the impact site. Increased speed gave a higher risk of haemorrhage. High speed injuries: Extensive subepidermal vascular congestion and extravasation of red blood cells. Bruises aged 4.5 h showed large numbers of neutrophils in the vessels of the subcutis and many were found around the capillaries and in the fatty tissue. Similar changes were absent/ less striking in bruises aged 2 h.	Randeberg *et al.*, 2007

many infiltrating neutrophils, respectively, in bruises aged 8 h. In comparison, Randeberg *et al.* (*2007*) reported many neutrophils around capillaries in the subcutaneous fat of bruises aged 4.5 h. Macrophages were already observed in bruises in mice after 3 h (*Takamiya et al., 2005*) while in calves and lambs macrophages were not present until 8 h after infliction (*McCausland & Dougherty, 1978)*. In addition, the time point at which macrophages became the dominating cell type was 48 h in calves and lambs, and 144 h in mice (*McCausland & Dougherty, 1978; Takamiya et al., 2005*). Moreover, McCausland & Dougherty (*1978*) noted that macrophages occasionally contained haemosiderin 24 h after infliction of blunt trauma. Takamiya *et al.* (*2005*) reported infiltration of lymphocytes after 72 h.

In the earliest animal models described by Hamdy *et al.* (*1957-1961*), chemical analysis was applied to measure haemoglobin and bilirubin in bruises in different animal species. Neither the concentration of haemoglobin nor bilirubin in the tissue seems useful for determining bruise age (Table 4). However, bilirubin was detected after 55 h in 2-5 month old rabbits, after 46 h and 10 h following three bruises in mammals and chickens, respectively (*Hamdy et al., 1975c,1960,1961a*).

In three reports, real time quantitative PCR was used to investigate mRNA expression of tissue-type plasminogen activator, skeletal troponin I and the sodium-coupled neutral amino acid transporter (SNAT2) (Table 5). In all three studies, blunt trauma led to changes in the expression of mRNA over time which could possibly be used to determine the age of bruises especially in the first 24 h after infliction. However, post-mortem degradation of mRNA may cause difficulties when estimating the age of bruises using quantitative PCR. Sun *et al.* (*2010*) reported that normal and bruised muscle from animals with bruises inflicted post-mortem had an expression of skeletal troponin I mRNA of about 70% of the control group indicating some degree of degradation of mRNA. In comparison, no post-mortem degradation of SNAT 2 in rat muscle tissue was observed (*Du et al., 2013)*.

Various other techniques have been used to estimate the age of bruises (Table 6). Several of these analyses have been able to measure some variation related to the age of the experimental bruises, but no

Table 4. Chemical and physical findings in animal bruise models

Species	Chemical and physical analysis	Reference
Cattle	Easily split iron: The concentration rose following trauma, peaked at day 5 (two fold increase) and decreased to control level within 7-9 days. Haemoglobin: The concentration increased immediately, peaked on day 4 (eight-fold increase) and decreased to the control level on day 9. Bilirubin: The control tissue did not contain bilirubin, while in bruised tissue the concentration reached 3.89 mg/100g within 4 days. By day 9, the concentration was 0.20 mg/100g.	Hamdy *et al.*, 1957a
Cattle	Colour reaction in Fouché's reagent: No blue colour reaction in bruises less than 50-60 h of age, light blue colour reaction in bruises aged 60-72 h and a dark green colour reaction in bruises 4-5 days old. Conductivity measurement: The conductivity of the tissue increased 15 min after bruising, peaked after 40 h, and decreased to normal in 7 days.	Hamdy *et al.*, 1957b
Rabbits Cattle Pigs Sheep	Effect of previous bruising: Bilirubin was detected earlier in the tissues following each subsequent bruise using Fouché's reagent (70 h, single bruise; 56 h, second bruise; 46 h, third bruise). Effect of a single bruise in different species: Bilirubin was first observed in 60 to 72 h old bruises. Effect of age: Bilirubin was detected at 55 h in the young animals but not in the older animals at this time point.	Hamdy *et al.*, 1957c
Chickens	Colour reaction in Fouché's reagent: In normal tissue no colour reaction was seen. 0-13 h: Pink turning brown. 14-24 h: Light blue. 24-36 h: Light green. 2-3 days: Dark green with a brown center. 3-4 days: Dark green spots/crystals. 5 days: No evidence of damaged area. Sometimes slight blue colour could be detected.	Hamdy *et al.*, 1960, 1961a
Chickens	Effect of age: Bilirubin was detected after 11 h in bruises in young chickens compared to 14 and 16 h for broilers and old birds, respectively. Effect of previous bruising: Bilirubin was detected after 10 h in the third bruise of chickens receiving three bruises. In chickens receiving two bruises, bilirubin was detected after 12 h in the second bruise. In chickens with only a single bruise, bilirubin was detected after 14 h.	Hamdy *et al.*, 1961b

Table 5. Evaluation of the mRNA expression of tissue-type plasminogen activator, troponin 1 and sodium-coupled neutral amino-acid transporter in animal bruise models using real-time quantitative PCR

Species	Real-time quantitative PCR	Reference
Mice	The mRNA expression of tissue-type plasminogen activator (tPA) peaked at 1 h post injury, was near normal at 8 h post injury, and increased again at 24 to 72 h. At 240 h post injury, the expression was near normal.	Takamiya *et al.*, 2005
Sprague Dawley rats	The expression of skeletal troponin 1 (sTn1) mRNA in muscle tissue after blunt trauma was measured. At 0.5, 1 and 6 h post-injury the expression of sTn1 was decreased 78%, 42% and 32%, respectively, compared to muscle tissue from an uninjured individual. There were no further significant changes during the experimental period (36 h).	Sun *et al.*, 2010
Sprague Dawley rats	At 4, 8, 12, 16, 20 and 24 h post-injury the mRNA expression of sodium-coupled neutral amino-acid transporter (SNAT2) was significantly increased. There were no significant changes in the expression of SNAT2 mRNA from 24 to 48 h after trauma.	Du *et al.*, 2013

Table 6. Evaluation of animal bruise models using various other techniques

Species	Analysis	Findings	Reference
Calves Lambs	Enzyme histochemistry	Alkaline phosphatase, acid phosphatase and leucine aminopeptidase failed to demonstrate differences between bruises of various ages.	McCausland & Dougherty 1978
Chickens	Colour measurement using a colorimeter	The change in L-value (the lightness) for all bruise locations peaked at 6 h. Wing bruises became less yellow and thigh bruises became more red as the age of the bruises increased.	Northcutt *et al.*, 2000
Mice	*In situ* hybridization	The tissue-type plasminogen activator (tPA) mRNA was detected in the epidermal cells, fibroblasts and endothelial cells before and after injury. In neutrophils and macrophages tPA mRNA was detected from 3 h and 72 h, respectively. In lymphocytes throughout healing and in neutrophils and macrophages at 240 h after injury tPA mRNA could not be detected.	Takamiya *et al.*, 2005
Pigs	Reflection spectroscopy Doppler ultrasound	Low speed injuries: Oxygenation, dermal blood volume fraction, and erythema index showed small changes after impact. High speed injuries: Haemoglobin oxygenation, erythema index and dermal blood volume fraction showed fast changes after the impact, followed by slow recovery. The dermal blood volume fraction peaked 10-15 min after impact, as measured in the central zone of the bruise. Doppler ultrasound showed an increased blood flow after impact, but no reservoir of blood could be seen in muscular tissue	Randeberg *et al.*, 2007
Sprague Dawley rats	Electric impedance spectroscopy	The right gluteus maximus was excised and the electric impedance of the tissue was measured. The electric impedance in bruises inflicted 1, 3 and 6 h before death was significantly lower compared to normal muscle tissue. The electric impedance decreased as bruise age increased.	Mao *et al.*, 2011

consensus about the value of the individual analyses has been achieved. However, from the histological evaluation of experimental bruises in animal models, there is consensus that neutrophils are the first type of cell to infiltrate the site of infliction. However, later the characteristics of cell infiltration vary considerably among animal bruise models. Therefore, based on the current animal models of bruises, extrapolating histological results between species is subject to uncertainty. In veterinary forensic medicine, it is an advantage that animal models for studying bruises in specific species can be established by using the species *per se*. These models are most comparable to the forensic cases for which they were developed. By contrast, in human forensic medicine, comparing bruises with experimental bruises in animals will be subject to some uncertainty. However, experimental bruises in animals will still most likely contribute to assessing the age of bruises in humans. Therefore, in the future an animal species with a high resemblance to humans, e.g. the pig with regard to anatomy, physiology and skin reactivity, should be the animal of choice *(Herron, 2009; Swindle et al., 2012)*. Unfortunately, this has hitherto not been explored in a satisfactory manner.

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