

Putative Mechanical Asphyxiation and Cerebral Cyst in a Sudden Death Changeable Hawk Eagle (*Nisaetus chirratus*)

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ABSTRACT

An adult changeable hawk eagle (*Nisaetus chirratus*) was found dead with no significant lesion. Previous health examination showed no abnormality suggesting that the bird underwent sudden death. Necropsy resulted no significant findings except intact living prey stuck at the upper digestive tract and nodular lesion accompanied with cerebral cyst in the cerebrum. Intact lizard body was found in the proventriculus suggesting that the bird showed odd feeding behaviour of failing to macerate the lizard. Thus, mechanical asphyxiation due to proventricular content compression was highly expected as the cause of this sudden death event. A cerebral cyst with nodular masses was present and might become space-occupying lesion in the cerebrum which distorted the cerebral parenchyma and affected the centre of neural response. Histopathology revealed that there were no proliferative reaction and neoplastic growth present. Hence, we presumed that the nodular masses came from outwards compression during the cyst formation.

Keywords: raptor, eagle, cerebral cyst, mechanical asphyxiation

ABSTRAK

Seekor elang brontok dewasa (*Nisaetus chirratus*) ditemukan mati tanpa adanya lesi signifikan yang teramati pada organ-organ superfisial dan visceral. Pemeriksaan kesehatan sebelumnya menunjukkan tidak adanya abnormalitas yang mengindikasikan bahwa elang mengalami kematian mendadak. Hasil nekropsi menunjukkan adanya lesi nodular disertai dengan kista cerebral pada cerebrum dan ditemukan pakan berupa kadal yang utuh pada saluran digesti bagian atas. Pakan yang masih utuh di sepanjang esofagus dan proventrikulus menunjukkan adanya perilaku makan yang abnormal dan memungkinkan terjadinya asfiksia mekanik akibat adanya kompresi ke trakea dan atau pulmo. Selain itu, terdapat sebuah kista cerebral dengan massa nodular pada cerebrum yang menyebabkan distorsi pada parenkim otak dan kemungkinan mempengaruhi fungsi saraf. Pemeriksaan histopatologi menunjukkan tidak adanya reaksi proliferasi dan pertumbuhan neoplastik. Massa nodular yang terbentuk diduga berasal dari kompresi keluar akibat pembentukan kista. Asfiksia mekanik menjadi dugaan terkuat yang memicu kematian mendadak pada elang ini.

Kata Kunci: raptor, forensik, kista cerebral, asfiksia mekanik

INTRODUCTION

An adult male changeable hawk eagle (*Nisaetus cirratus*) was found dead with the body laid on the cage floor in dorsal recumbency without any external lesion or traumatic injury. This eagle was fed twice with lizard on the day of death; morning feeding around 8.00 am and afternoon feeding at 1.00 pm; and was found dead at 1.25 pm. Information retrieved from animal keepers showed that this eagle was normally preying for the lizards with no suspicious behavioural disorder or gross physical abnormality.

A general health examination was performed on this eagle a day before, including collecting blood sample, physical examination, and morphometry according to a routine procedure. No complication was ever reported in other eagles we previously examined since commencing the annual raptor health check. The heart and respiration rates were 140 and 40 times per minute consecutively. The body temperature was measured at 36.1°C. All organ systems were apparently in normal condition except the pectoral muscle, which was palpated very thin and concave, with body condition score (BCS) 2 out of 5. The body weight was approximately 800 grams. The blood reference interval of changeable hawk eagle is not yet available in Indonesia, thus, we rule out the haematologic finding from our evidence list.

The body was then stored in the freezer about an hour prior to necropsy procedure being held. No additional sample from the cage was taken for further ancillary test. The disease investigation protocol was then performed to seek for the most possible cause and way of death of the deceased eagle.

MATERIALS AND METHODS

The investigation and specimen collection of this deceased eagle have been approved by Ministry of Environment and Forestry of Indonesia through permit number SK.196/KSDAE/SET.3/KSA.3/10/2020 and under ethical clearance document number 022-KEP-UB-2023. The necropsy was immediately conducted following the standard avian necropsy procedure (Garcês & Pires, 2020) two hours after the body was retrieved to prevent the subsequent autolysis and putrefaction. The eagle's head was decapitated and was re-stored to the freezer for the brain extraction next day. We slowly thawed the frozen head in the room temperature for about three hours before conducting the brain extraction. The brain was extracted by chipping the skull following the common method using a bone cutting forceps to expose the calvarium. Once the roof of the skull removed, the head was flipped down and a curved

blunt-end scissors was inserted into the bottom of cranial cavity to cut the cranial nerve branches. The extracted brain was then submerged in 10% non-buffered formalin for next 5-day fixation. We were performing bread-loaf trimming after the brain was thought to completely fixed to see any intracerebral lesion. The prefixed brain and after trimming result are depicted in Figure 2.

The brain specimen was then run for tissue processing and stained using routine Haematoxylin (Harris)-Eosin protocol. Modification was made for clearing period in tissue processing stage with following consecutive regimen: absolute xylene I (10 minutes), absolute xylene II (10 minutes), and absolute xylene III (20 minutes).

RESULTS

Gross Findings

Once we opened the upper digestive tract, the whole body of a lizard given during feeding time was found intact stranded along from oesophagus to the proventriculus. The lizard's head was off, but the large portion of its body seemed likely impacting the stomach orifice. The intestine was filled by ingesta and another lizard given seemed completely digested. Figure 1 depicts the dissected lower oesophagus and proventriculus containing the intact lizard's body. No significant lesion was discovered except some lesions in the liver and brain. The following sections present the pathological change specifically found in the liver and brain.

There is an approximately 2 mm in diameter, moderately demarcated, yellow, focal, flat, firm, round lesion in the visceral surface of left liver lobe. There are also three, measured < 1 mm in diameter, well demarcated, yellow, multifocal, flat, firm, round pinpoint lesions in the visceral surface of right liver lobe. Moderate yellow discoloration was also encountered in both lobes approximately affecting 30% of liver's surface. The lobes palpation revealed the increase of parenchyma tissue rigidity (hardening) suggesting to hepatic fibrosis or cirrhosis or solely postmortem change. Transverse section showed no significant change but moderate blood clot oozing from the parenchyma. The lesions in liver are depicted in Figure 1.

We figured out at least four lesions from this gross brain examination. The most distinctive lesions are an empty cavity resemble a cyst located in the parenchyma of right cerebral lobe and a tumour-like nodule growing up from the right cerebral hemisphere. There are actually two visible cyst-like lesions measured approximately 1 x 3 mm and < 1

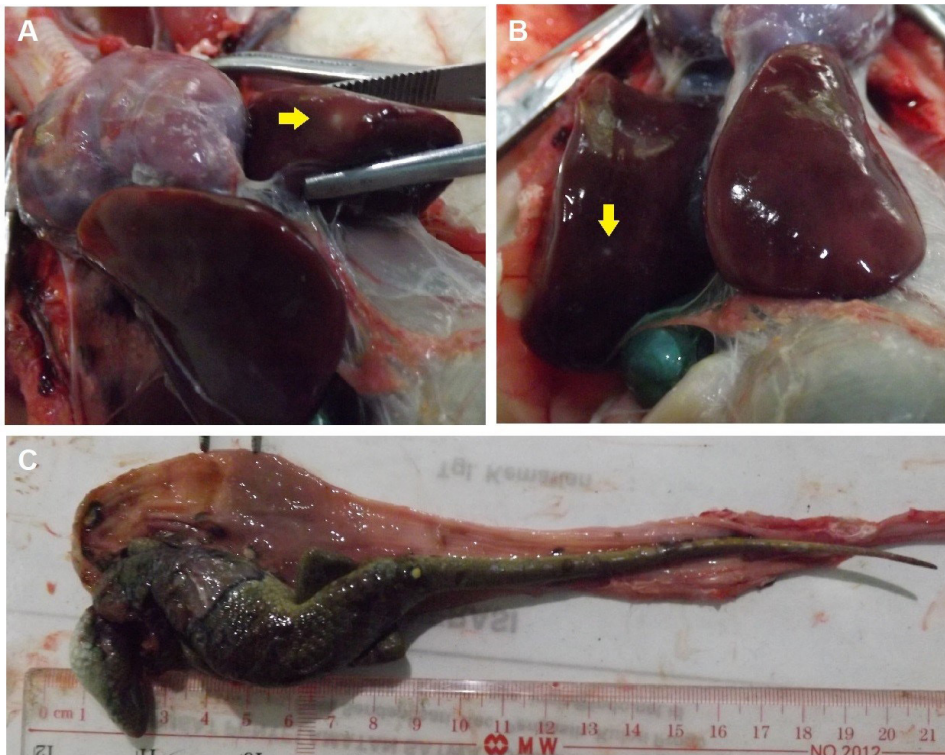


Figure 1. Upper image shows the yellow circular lesions in the visceral surface of liver (figure A and B, yellow arrow). Bottom image (figure C) depicts the intact body of lizard as the content of proventriculus. Putative gross morphological diagnosis: mild multifocal necrotizing hepatitis, mild multifocal hepatic necrosis.

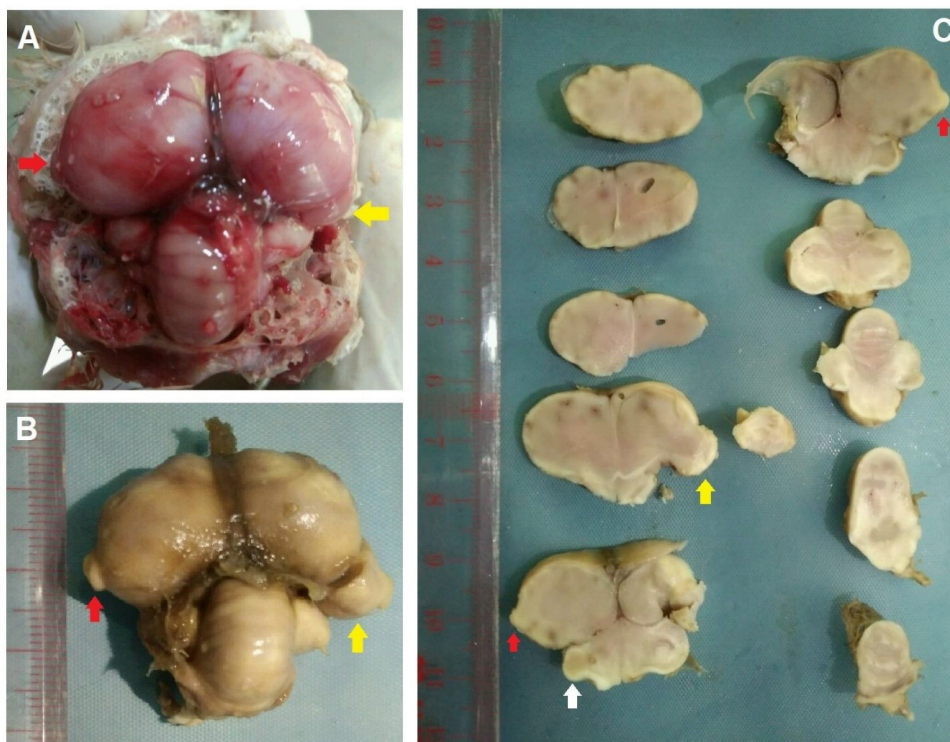


Figure 2. The presence of tumour-like nodules growing up from both cerebral hemisphere (figure A and B, red and yellow arrows), cyst-like empty cavities, and shrinkage of the left optic lobe (figure C, white arrow). Note several brown discolorations in the roof of cerebrum. Putative gross morphological diagnosis: multifocal cerebral tumour, multifocal intracerebral cyst, optic lobe necrosis, multifocal intracerebral haemorrhage.

mm in diameter respectively in the first quadrant of cerebrum and at the top of right cerebral lobe near to the interhemispheric fissure. Unfortunately, the cyst content is possibly washed out.

At least two nodular lesions are encountered in the cerebrum. There is an approximately 2 x 4 x 3 mm, focal, well-demarcated, whitish, irregular, firm nodule rising from left hemisphere of cerebrum. There is also a 5 x 7 x 8 mm, focal well-demarcated, whitish, round, firm nodule bulging out from right hemisphere of cerebrum. The layer demarcation of cerebral parenchyma shows that both inner and outer layer are composing this nodular lesion. The left optic lobe is also reduced in volume with brownish discoloration compared to right optic lobe. There are six, up to 2 mm, randomly distributed, poorly demarcated, multifocal to coalescing brownish discoloration found in the cerebrum. A brownish discoloration was also spotted at the first sight of brain extraction at the anterior surface of left cerebral lobe (Figure 3).

Histopathologic Findings

Histopathologic description reveals significant formation of a cerebral cyst and a dilated vessel whereas no proliferative cell indicating neoplastic feature is present. The density of cell population composing the cerebral parenchyma is relatively even. No clustered hypercellularity observed even in the nodular portion that protrudes from left hemisphere.

The fact that the ingested lizard was still relatively intact led to the assumption that the eagle dead just after swallowing the whole body of a latest lizard given. In addition, it is also a strange behaviour

that the eagle did swallow the intact lizard's body instead of tearing it apart first. Since the excessive load of oesophagus may compress the trachea and eventually blocks the airway, mechanical asphyxiation due to tracheal compression is listed in our differential diagnosis list. A putative pathogenesis of this case is established as presented in figure 5.

DISCUSSION

At the moment, it is relatively difficult to track back the health history of eagle with very limited documented health report and data available in the rescue centre. Mechanical asphyxiation might be the highly likely cause of death due to tracheal compression by the overly dilated oesophageal-proventricular tube. The similar symptom was also present in case of achalasia (Perez-Colon *et al.*, 2017). Mechanical asphyxiation is described as respiratory motility restriction due to postural manipulation or trauma (Sauvageau & Boghossian, 2010). Two types of mechanical asphyxiation have been proposed to indicate the rationale of this condition: positional and traumatic asphyxiation (Sauvageau & Boghossian, 2010). Considering the presence of potential compression to the trachea and lungs, it is suggested to classify this case as traumatic asphyxiation.

The sudden death of eagle was also ever reported as the result of obesity or fatty liver syndrome which is also commonly reported in poultry due to imbalance nutritional diet (Forbes & Cooper, 1993). Communication with our colleague from a local zoo revealed that the sudden death of eagle is not only happening in our centre. Emaciation marked by very

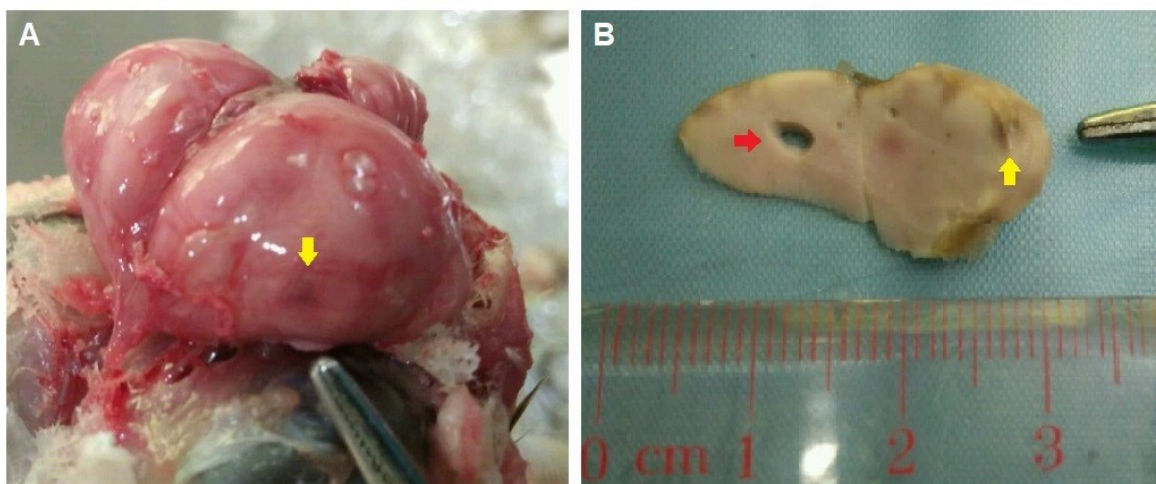


Figure 3. First spotted lesion during brain extraction came up as poorly demarcated, brown, focal, irregular discoloration at the anterior of left hemisphere surface (figure A, yellow arrow). Notice the cavity formed in the right cerebral lobe (figure B, red arrow). Putative gross morphological diagnosis: focal superficial cerebral haemorrhage.

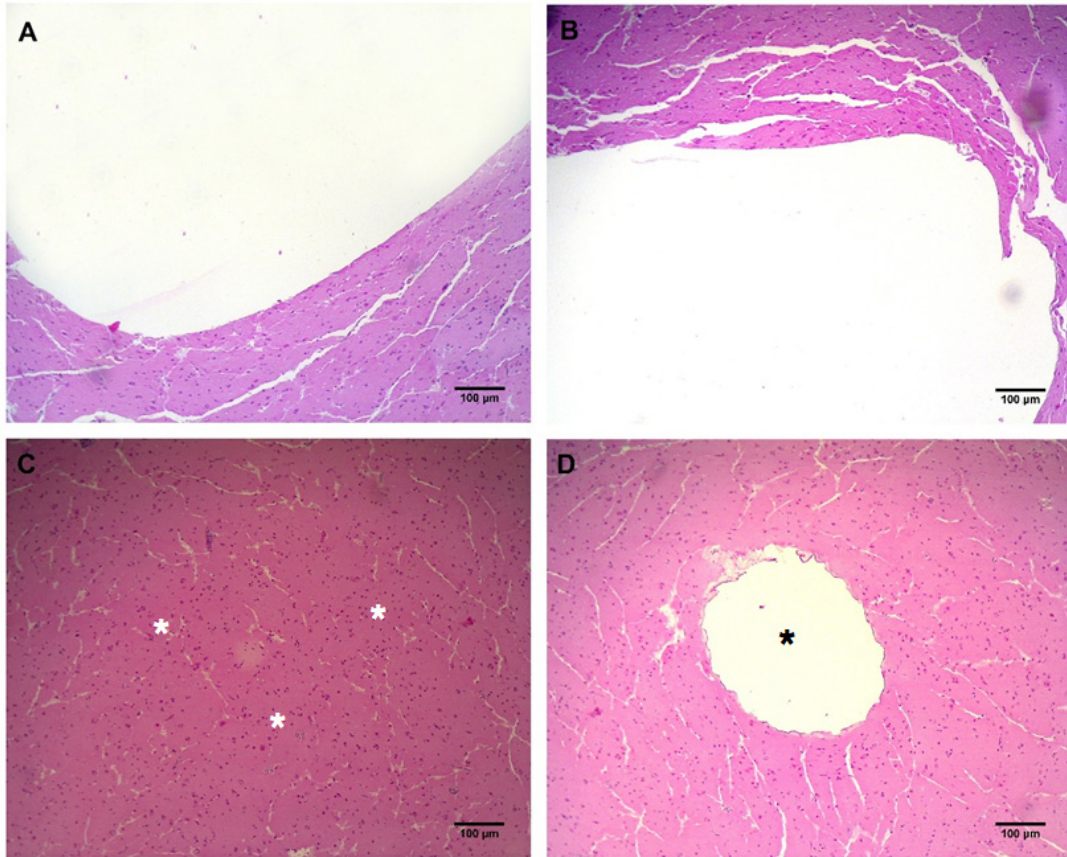


Figure 4. The histopathology of cerebral cyst with routine haematoxylin-eosin staining (figure A and B) shows the empty circumferential space surrounded by cerebral parenchyma. Figure C presents the even density of cell population in grey matter containing neurons (white asterisks) and glial cells. Dilated vessels (black asterisk) are also occasionally observed (figure D). Parenchyma cracks are possibly due to the fixative effect.

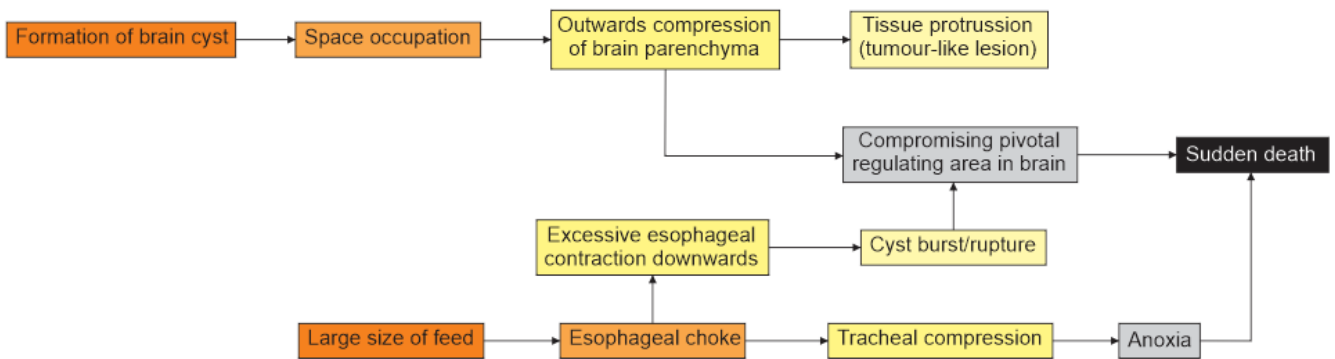


Figure 5. Deduction of case pathogenesis in this deceased changeable hawk eagle emphasizing the potential mechanical asphyxiation and neural damage due to cerebral cyst formation

thin pectoral muscle with low body condition score is commonly encountered in sudden dead eagles previously found in that zoo though the diet has been regularly assessed and it is considerably sufficient to maintain their daily metabolism. It was firstly thought that there may be a problem on the digestive system but no lesion or endoparasite was encountered

during our necropsy. *Haemoproteus* infection was also reported causing sudden death in passerine birds (Donovan *et al.*, 2008) and infection in raptors have been reported in several cases with none of clinical sign and lethal case is reported.

The flat yellow pinpoint lesion in liver is very typical to hepatocyte necrosis or early development of focal

necrotizing hepatitis (Zachary & McGavin, 2016; Dutta et al., 2015). It needs to be proved by histopathology finding to support this diagnosis. The common agents causing this lesion are bacteria (*Pasteurella*, *Salmonella*, *Histomonas*) (Dutta et al., 2015; Abdullar et al., 2014; Ghaly et al., 2017) and possibly toxin. However, to the best of our knowledge, the mild infection is rarely causing sudden death in avian species.

The key lesion is possibly located in the brain: the tumour-like nodule and former cyst cavity. The tumorous mass always compresses the adjacent tissue and, in the case of brain tumour, it increases the intracranial pressure which alters the vascular permeability and pressure, leading to the local oedema, shape distortion or eventually tissue damage (Bogdanovic et al., 2011). We deduced that, in this case, the cyst size already contributed to deformation and outward protrusion of small portion of right hemisphere, thus also increased intracranial pressure. Cancerous tissue also creates expansive weak vasculature arrangement which is prone to endothelial destruction and eventually haemorrhage (Babu et al., 2016). If the mass is located in the pivotal centre of consciousness or other important organ system regulator in the brain, a sudden movement or impact can impair the cancerous mass integrity causing unexpected neural damage and dysfunction and eventually death. The origin of the cavity is still poorly understood, however, considering the fact that the intracerebral mass may develop oedema, localized interstitial fluid accumulation may initiate a cyst formation in the brain. Other intracerebral cyst ever reported in sudden death case in human are colloid cyst though it is less likely to occur in this case (Babu et al., 2016). Low grade astrocytoma is on our differential diagnosis list due to the low malignancy and relatively low density of cellularity of astrocytes (Kros et al., 2015). It is difficult to estimate the normal density of neuron and glial cells in avian brain; however, to the best of our knowledge, there is no significant difference between cellular density in the protruding mass and in other areas of eagle's cerebrum. Astrocytoma was ever reported in green-cheeked conure (*Pyrrhura molinae*) however the histopathological presentation is way different from our finding (Carleton et al., 2004). Considering that no significant incoordination or neural problem was reported prior to death, we deduced that this cyst formation might not directly affect and contribute to the deceased event of the bird.

Cerebral cyst is rarely reported in birds especially in raptor species. Reflecting the presentation of abnormal fluid-filled-sac formation in pancreas, the histological architecture of our finding is more identic

to pseudocyst – while true cyst is always lined by epithelial cells (Parihal & Gulve, 2021). Various cyst categories are present in cutaneous cyst, though the formation might undergo different pathways (Pérez-Muñoz et al., 2019). In bird species, parasite-associated-cyst is identic to *Sarcocystis spp.*, however muscles are more to be prevalent predilection of this parasite. Jakob et al. (1998) also reported the presence of brain cyst in various size due to infestation of *Sarcocystis kirmsei* in a hill mynah (*Gracula religiosa*). Bamac et al. (2020) reported sarcocystosis in Brandt's cormorants (*Phalacrocorax penicillatus*) though only schizonts instead of cyst stage were found in brain parenchyma. Both cases presented various degree of neuronal damage and its manifestation to birds' physiology due to the encephalitis and neuronal necrosis. Massive presumed peripheral brain cyst formation was also ever reported in crested Peking duck (*Anas platyrhynchos*) located in meninges layer and already triggered neuronal defect (Yaw et al., 2016). In a very occasional case, brain tumour might induce cystic formation as reported in White Leghorn chicken with cerebellar teratoma (Jones, 1964). *Toxoplasma gondii* is other parasitic protozoa capable inducing brain cyst formation in birds as reported in small passerine and exotic birds (e.g. *Carduelis carduelis*, *Carduelis cannabina*, *Serinus canaria*, *Carduelis chloris*, *Carduelis spinus*, *Pyrrhula pyrrhula*) (Parenti et al., 1986; Garnham et al., 1979).

The presence of sudden death event in wild animal in captive facility like a wildlife rescue and rehabilitation center like ours emphasizes the concern to perform routine examination regularly – regardless of whether there are sick animals – is pivotal to screen the health status of each individuals in the facilities. Wild animals naturally conceal their pain to avoid the predator. Diseased, young, and geriatric animal are prone to be hunted at first place, thus, they tend to hide their pain. Unfortunately, this behaviour is also expressed in their captivity, making keepers and veterinarian unaware to any subtle clinical sign manifested from physiological failure. The sick individuals might exhibit the pain at a latest stage of a disease, leading to an apparent presentation of sudden death or untreatable condition. At this state, intervention is less useful and prognosis is mostly poor which often remains a final choice - euthanasia. Thus, we strongly encourage performing routine health examination as pre-emptive action to prevent a progression of an untreatable illness in captive wild animal. Barrows et al. (2017) suggested eight actions for implementing preventive medicine in zoo including quarantine consisting of pre-departure and post-arrival testing, regular faecal test and deworming, ectoparasite control,

vaccination, routine health examination, neonatal and geriatric health test, post mortem investigation, and prophylactic pre-emptive treatment.

Based on significant gross change and histopathologic examination, the most probable cause of death of this eagle was mechanical asphyxiation due to the compression of excessive oesophageal content followed by the formation of cerebral cyst and the presence of cerebral mass adjacent to aforementioned cyst. We deduce that this nodular mass might rise due to the outward compression of cyst formation and space occupation. Sudden movement or traumatic contusion in the calvarium might damage the cyst and impair the adjacent neurons leading to neural damage.

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“All authors declare that there are no conflicts of interest”.

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