Diagnosis of Pelvic Injuries Using Computed Tomography in A Rowi (Okarito Brown Kiwi)

Brett Gartrell, Kerri Morgan, Clare Green, Mark Owen, Rachel Berry, and Marc Khull

Introduction

The advantage of computed tomography (CT) over conventional radiography is its ability to produce a two dimensional image that does not have overlapping structures (Krautwald-Junghanns et al 1998). Common indications for CT scanning include investigation of complex structures such as the skull, spine or in this case the avian synsacrum. The ability of modern CT systems to create three dimensional image of the structures scanned is downplayed by radiologists but we found it a valuable tool for the clinician in visualising the extent and severity of injuries. The 3-D modelling also aids in comprehending the anatomy of unfamiliar species.

Rowi (Okarito brown kiwi) *Apteryx rowi*, are a critically endangered kiwi species with a precarious single population of approximately 250 birds. The birds are confined to a small area (11,000 ha) of forest on the west coast of the South Island of New Zealand. The young birds have been decimated by introduced predators, mainly mustelids, and conservation efforts are centred around predator control and artificially incubating eggs and rearing chicks in captivity before re-introducing them to the wild. Adult survival is normally very high (http://www.savethekiwi.org.nz).

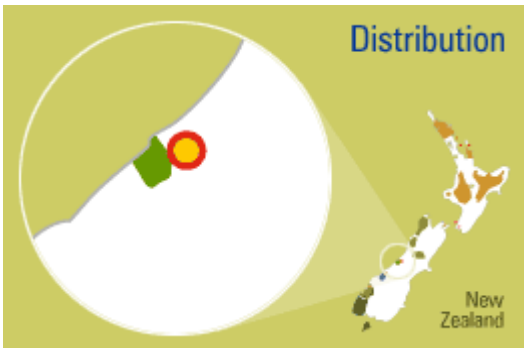

Figure 1. Distribution of the rowi *Apteryx rowi* within New Zealand.
Source: (http://www.savethekiwi.org.nz).

This paper documents the value of CT scanning in characterising pelvic fractures in an endangered kiwi species, and further highlights the need to retain the holistic approach to cases that involve advanced imaging.

Case History

A three year old, female Rowi (*Apteryx rowi*) was struck by a car. The bird was left sitting by the side of the road and the local Department of Conservation officers made the unfortunate decision to monitor it in the bush for a week. The bird did not move far in this time and was observed to be not using its left leg and not feeding.

A local veterinarian (RB) examined the bird and found her to be bright, alert and strong. There was crepitus over the bird's left hip, with marked bruising and soft tissue swelling evident. There were proprioceptive deficits as evidenced by knuckling of the left digits and the bird would not weight bear on the left leg. The right leg was normal in tone, strength, neurological exam and weight bearing. Radiographs showed no significant changes on the lateral view and an an ill defined opacity of the left acetabular rim suggestive of a fracture on the ventro-dorsal image.

The bird was given butorphanol at 4mg/kg IM and oral fluids before being transferred to the Wildlife Ward at the Massey University Veterinary Teaching Hospital.

Clinical Findings

On arrival at the Wildlife Ward, clinical findings were similar to that of the referring veterinarian, except that the bird was now depressed and the mucous membranes were pale. The bird was placed on IV fluids and butorphanol (4 mg/kg bid IV) via the medial metatarsal vein of the right leg and confined in a padded area. Bloods were taken for haematology and biochemistry and the bird was given 24 hours for transport stress to subside before further diagnostics were pursued.

Table 1. Haematology and biochemistry from a Rowi seven days after being hit by a motor vehicle and transport to Massey University. Reference ranges for North Island brown kiwi from Doneley (2006).

Haematology		Units	Reference range (NI Brown kiwi)
HCT	0.24	L/L	0.38-0.54
Haemoglobin	109	L/L	
WBC	7.0	$X10^9$ cells	8.7-14.5
	Diff (%)	Absolute ($X10^9$ cells)	
Heterophils	89	6.23	4.0-8.2
Lymphocytes	6	0.42	2.5-5.9
Monocytes	4	0.28	0.1-0.5
Basophils	1	0.07	0.09-1.3

Serum biochemistry			Reference range (NI Brown kiwi)
Uric acid	120	umol/L	0-380
CK	8771	IU/L	521-971
AST	757	IU/L	64-138
ALT	276	IU/L	
Total protein	38	g/L	54-62
Albumin	14	g/L	
Globulin	24	g/L	
A/G ratio	0.60		
Calcium	2.3	umol/L	1.8-3.1
Phosphorus	1.4	mmol/L	
Sodium	147	mmol/L	139-159
Potassium	4.3	mmol/L	2.2-3.7
Urea	1.4	umol/L	

The problem list at this point included:

1. Non-weight bearing left leg lameness with proprioceptive deficits and hip crepitus
2. Blood loss anaemia and hypoproteinaemia
3. Chronic traumatic myopathy associated with motor vehicle trauma

Imaging

Radiographs were repeated 24 hours later. A veterinary radiologist reviewed these and previous films and was unable to discern any obvious fractures to pelvis or hind legs (Figures 2 and 3). On

the left side there appeared to be some irregularity or fragmentation adjacent to the cranial acetabular edge, but the radiologist warned that the interpretation should be viewed with caution.

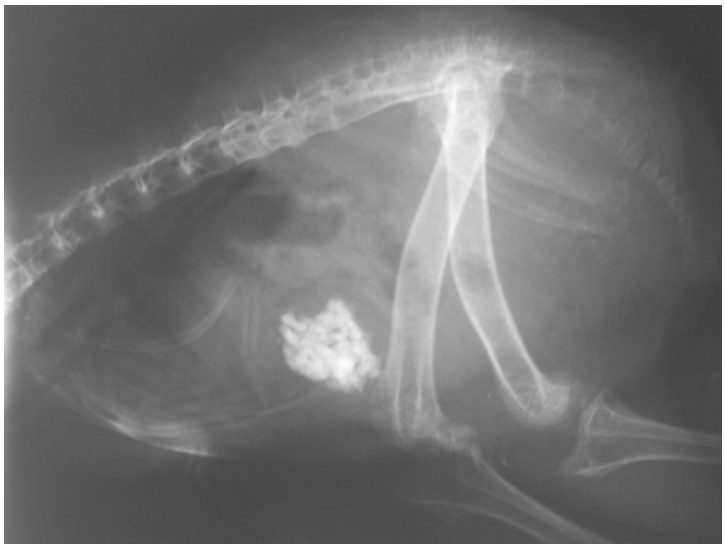

Figure 2. Lateral radiograph of a rowi kiwi.

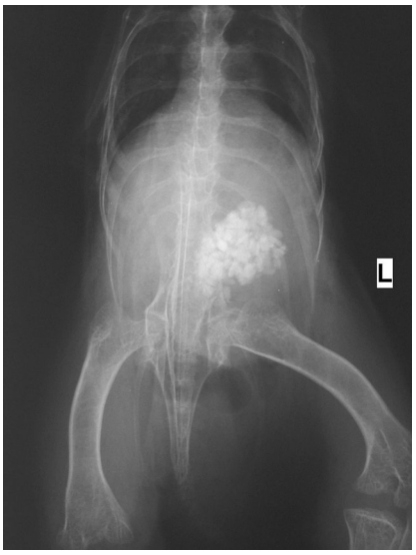

Figure 3. Ventro-dorsal radiograph.

Given this uncertainty, and the need to accurately assess the injuries, the kiwi's pelvis was imaged using computed tomography (Figures 3, 4 and 5). Sections through the pelvis clearly demonstrated the fracture and medial displacement of the left acetabular rim.

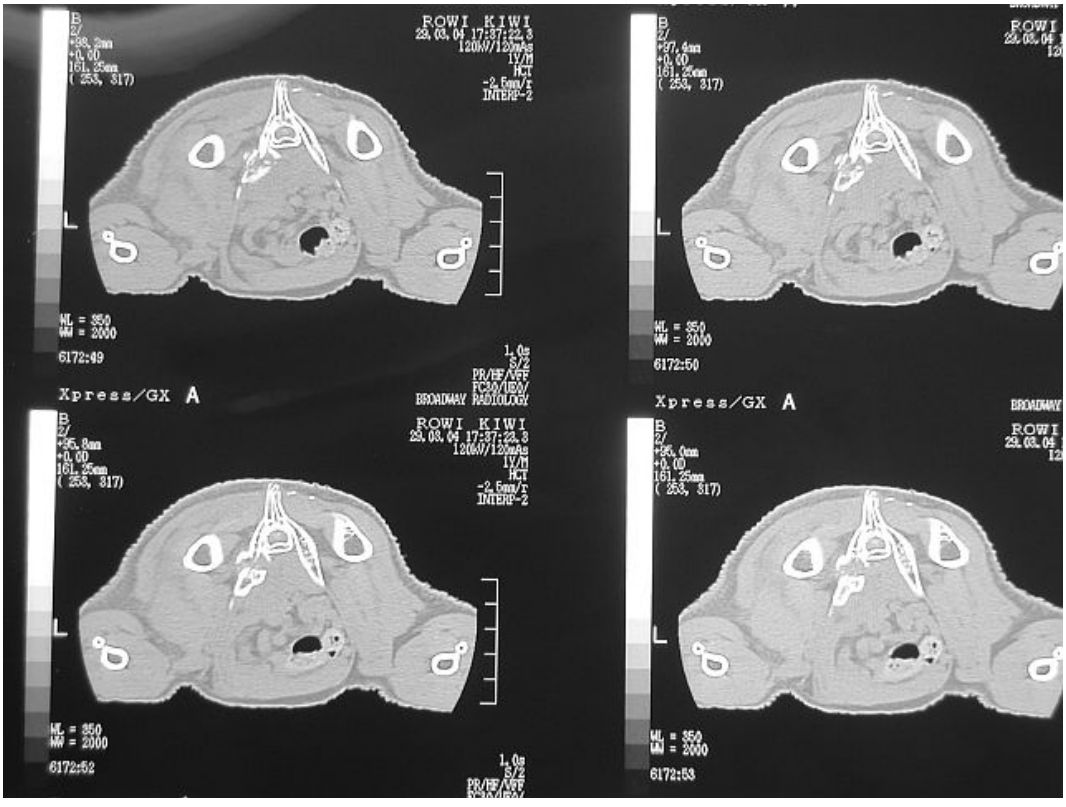

Figure 4. Computed tomography slice images from the pelvis of a Rowi kiwi with an acetabular fracture.

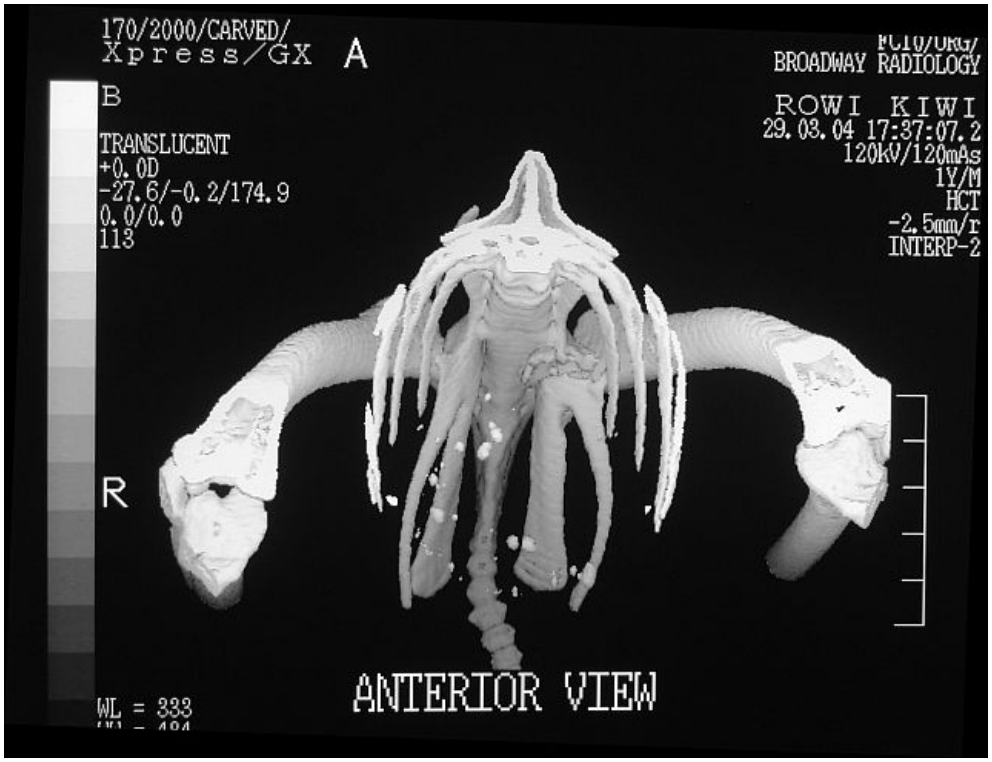

Figure 5. Three dimensional reconstruction using computed tomography of the pelvis of a Rowi kiwi with a left acetabular fracture. Note the mineralised grit in the gastrointestinal tract.

Treatment

We opted to undertake conservative treatment of the acetabular fracture consisting of padded cage rest, fluid therapy, nutritional supplemention and continued analgesia with butorphanol and meloxicam (0.2 mg/kg sid po). After approximately seven days, the bird was placed intermittently in a sling and gentle physiotherapy (bicycling) of the hip was commenced qid.

Fourteen days after admission, the kiwi exhibited sudden onset of dyspnoea which worsened despite oxygen supplementation and treatment with antibiotics (amoxicillin/clavulonate 50 mg/kg bid po, enrofloxacin 15 mg/kg bid po), antifungals (itraconazole 10 mg/kg bid po) and nebulisation with amphotericin B bid. Forty eight hours after the onset of dyspnoea the kiwi died.

Post mortem findings

The kiwi was in fair body condition with adequate reserves of subcutaneous and abdominal fat. There was a multifocal distribution of pinpoint cream lesions on the liver surface. The lungs were wet and congested. The kidneys were enlarged and pale, with the left caudal lobe containing an abscess underlying the site of the acetabular fracture.

On histopathological examination, there was severe congestion of the pulmonary tissue. There were several granulomatous foci throughout the lung parenchyma consisting of a central core of necrotic cells containing many fungal elements. At the periphery of these lesions, there were many mononuclear cells with the occasional granulocyte. Many of these lesions were within or adjacent to parabronchi. There were numerous foci of leukocyte infiltration throughout the lung, and there were especially large areas adjacent to the granulomas.

There was complete avascular necrosis of almost the entire section of the left caudal lobe of the kidney, containing no red blood cells. At the margin of the kidney capsule, there was an extensive accumulation of necrotic mononuclear cells and granulocytes. Throughout the remaining kidney, there was hyperplasia of vascular walls. There were also scattered foci of mononuclear cells and the occasional granulocyte.

The post mortem diagnosis was:

1. Pneumonia - chronic, fungal, granulomatous.
2. Renal avascular necrosis.
3. Hepatitis – granulomatous
4. Left acetabular fracture

Discussion

It is unclear when the avascular necrosis of the left kidney occurred. The medial displacement of the acetabular rim was present when the CT scanning was done, which suggests that some renal damage occurred during the initial injury and subsequent transport. What remains uncertain is firstly whether physiotherapy contributed to the renal necrosis by movement of the femoral head in the shattered acetabulum, and secondly whether femoral head and neck ostectomy would have prevented such damage.

There was considerable debate and divergent opinions as to the best course of treatment, with the main discussion centering around whether to continue conservative treatment or to undertake a femoral head and neck ostectomy (FHO). While FHO is a recommended treatment for coxo-femoral luxations in perching birds (Bennett 1997), there is a lack of information on the effectiveness of FHO in large bipedal birds.

Initial serum biochemistry gave no indication of renal compromise at admission, but no follow up bloods were taken. In birds, it has been postulated that plasma uric acid levels will not become consistently elevated until 70% or more of renal reserve is compromised (Speer 1997). In this case, the right kidney was unaffected and there was presumably enough functional reserve to control plasma uric acid concentration. Ultrasonographic examination of the kidneys may have aided in detection of the renal damage.

Techniques of supplementary feeding of kiwi have evolved since this case, due to a high incidence of regurgitation and aspiration with liquid feeding. We now only use liquid tube feeding for kiwi with oro-facial injuries. Kiwi have no crop and the gizzard is often full of stones and grit material, reducing the volume available for liquid feeds. Our current supplementary feeding technique is to place “rissoles” of the artificial kiwi mix in the proximal pharynx and allowing the birds to swallow these back.

Computed tomography clearly demonstrated its value in the evaluation of damage to the complex skeletal structures of the kiwi synsacrum. Our mistake in this case was in under-estimating the degree of soft tissue injury associated with the skeletal damage. CT imaging does have the capability to evaluate a range of soft tissue densities but we were focussed on the skeletal injury and ignored this capability. This case reinforces the veterinary adage that where there is fracture, there is soft tissue injury.

Acknowledgments

The authors wish to thank Shell NZ for financial support of the Wildlife Ward, Broadway Radiology for the CT scanning, the Department of Conservation and the Ngati Tahu people for allowing us to treat the bird, and Maurice Alley for the pathology.

References

Bennett RA. 1997. Orthopedic surgery. In: Altman RB, Clubb SL, Dorrestein GM, Quesenberry K. (Eds) *Avian medicine and Surgery*. Pp 733-766. WB Saunders, Philadelphia, USA.

Doneley RJ. 2006. Management of captive ratites. In Harrison GJ, Lightfoot TL (Eds) *Clinical Avian Medicine.* Pp 957-990. Spix Publishing, Inc. Florida, USA.

Krautwald-Junghanns ME, Kostka VM, Dörsch B. 1998. Comparative studies on the diagnostic value of conventional radiography and computed tomography in evaluating the heads of psittacine and raptorial birds. *Journal of Avian Medicine and Surgery* 12, 149-157

Speer BL. 1997. Diseases of the uro-genital system. In: Altman RB, Clubb SL, Dorrestein GM, Quesenberry K. (Eds) *Avian medicine and Surgery*. Pp 625-644. WB Saunders, Philadelphia, USA.

How the Kiwi Lost His Wings

(Maori legend - http://www.savethekiwi.org.nz/KiwisSavingKiwi/Tane.htm)

One day, Tane Mahuta was walking through the forest when he noticed his children, the trees, were beginning to sicken as bugs ate them. He talked to his brother, Tane Hokahoka, who called all of his children, the birds of the air, together. Tane Mahuta asked that one of the birds should come down from the forest roof and live on the forest floor to help save his children, the trees. Not a bird spoke so Tane Hokahoka asked each one in turn whether they would come down from the forest roof.

Tui refused. He was afraid of the darkness down on the ground, away from the sun. Pukeko refused. He found the forest floor too cold and the earth too damp.
Pipiwharauroa, the shining cuckoo, refused. He was too busy building his nest.
But Kiwi agreed. He looked at the sun filtering through the high leaves, he looked at the damp cold earth, and he looked around and saw his family. And still he agreed.

Great was the joy in the hearts of Tane Hokahoka and Tane Mahuta, for this little bird was giving them hope. But Tane Mahuta felt he should warn Kiwi of what would happen.
"E Kiwi, do you realise that if you do this, you will have to grow thick, strong legs so that you can rip apart the logs on the ground. That you will loose your beautiful coloured feathers and wings so that you will never be able to return to the forest roof. You will never see the light of day again."
And still Kiwi agreed.

Then Tane Hokahoka turned to the other birds and said, "E Tui, because you were too scared to come down from the forest roof, from now on you will wear two white feathers at your throat as the mark of a coward. Pukeko, because you did not want to get your feet wet, you will live forever in the swamp. Pipiwharauroa, because you were too busy building your nest, from now on you will never build another nest again, but lay your eggs in other birds' nests.

But you Kiwi, because of your great sacrifice, you will become the most well known and most loved bird of them all."