Members of the Fish and Aquatic Mammal Section (from left to right): Haruka Suzuki, veterinary nurse, Sayuri Shimoyama, veterinary nurse, Ikue Hamasaki, assistant veterinarian, Makio Yanagisawa, veterinarian and Keiichi Ueda, veterinarian.

Okinawa Churaumi Aquarium: Imaging Marine Animals with the SOMATOM Spirit

Okinawa Churaumi Aquarium ranks among the five largest in the world and has achieved a long list of "bests" and "firsts". Now Churaumi Aquarium has become the first aquarium in Japan to use a CT scanner, specifically to diagnose marine animals.

By Katharina Otani, PhD, Tetsuo Onishi, Takumi Katsuya

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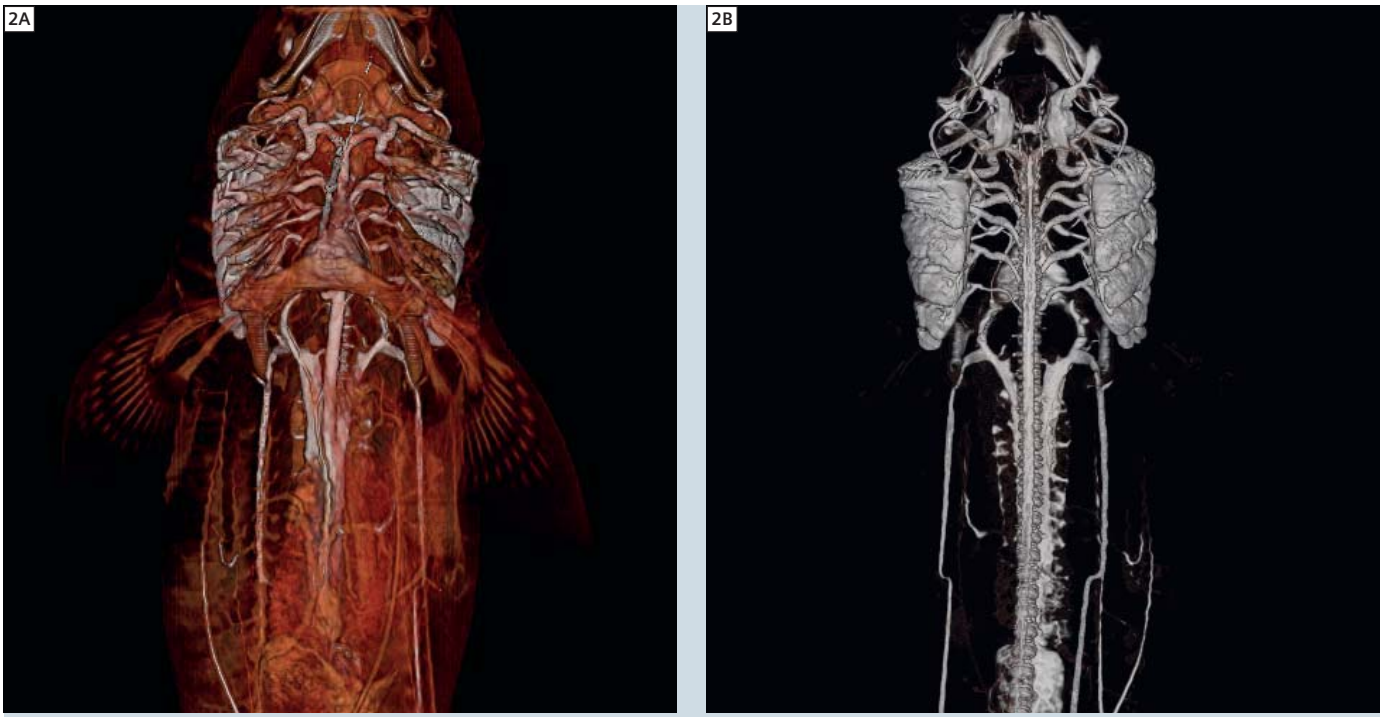
Okinawa Churaumi Aquarium is one of the few aquariums that successfully keep whale sharks and the first to breed manta rays in captivity. Little is known about computed tomography of marine animals. For scientific purposes, a SOMATOM® Spirit scanner was installed at Churaumi Aquarium in January 2008. Drying and conditioning the CT room was a major challenge as it is located next to changing rooms where staff members keep their wet suits. In addition, a door – used to bring in living fish in water tanks into the CT room – connects directly to the outside – and the weather is usually humid and warm in tropical Okinawa. The CT scanner also needed extra protection as marine animals are usually dripping seawater. To prevent corrosive seawater leaking into the gantry electronics, all joints were insulated with extra silicon

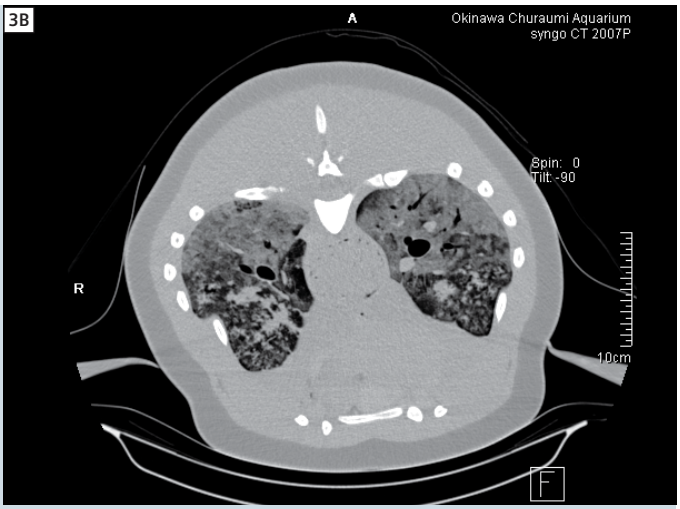
tape and a cover, made from wet suit material, protects both the patient table and mat from water and turtle's claws.
The veterinarians Keiichi Ueda and Makio Yanagisawa at Churaumi Aquarium together with Tetsuo Onishi from Siemens Asahi Medical Technologies adjusted the scan protocols by comparing fish to human sizes and shapes. After several trial and error scans of dead fish, they were able to save suitable scan protocols. Ikue Hamasaki recently joined the team as an assistant to the veterinarians. She earned a radiotechnologist license before studying marine biology at the University of North Carolina at Wilmington. "Scanning fish with a CT is easier than taking X-rays," she says, "because positioning is less critical. But unexpected artifacts appear in the CT images, for example, because shark skin is very thick. Also, immobilizing marine animals is challenging."
Time is critical when scanning living fish since some fish survive only a few minutes outside of water.
Veterinarian Yanagisawa recently succeeded in confirming the blood circulation of a Chiloscyllium punctatum (often called "brown-banded bamboo sharks"). After sedating the shark, he injected 20 ml of iodinated contrast bolus directly into the shark's two-chambered heart. The shark was lifted onto the patient table, positioned, and fixed before being scanned. The scan revealed that blood is pumped into the arteries and then flows to the gills. From there, it spreads directly into the shark's whole body. The venous blood flowing back to the heart is faster than the arterial blood spreading into the body. Not all fish can be sedated, but Chiloscyllium punctatum are robust marine animals that tolerate anesthesia and contrast injections well. After the scan, the sedated shark was cradled inside seawater until it woke up and could soon be put back into the main tank.

Development of Treatment Plans

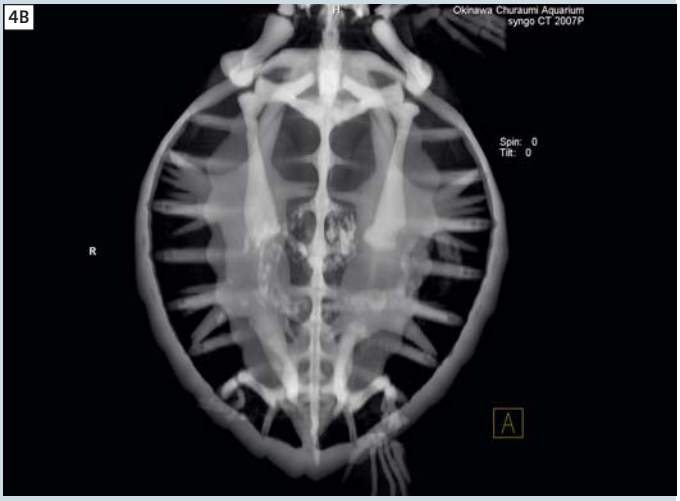
Veterinarian Ueda also uses CT for diagnosing and healing sick marine animals. Dissections and virtual autopsies help in understanding the cause of death of an animal, if organisms could be routinely scanned, treatment plans could be decided to save animals. This became possible with a CT installed on the Aquarium premises. Last year, Ueda could diagnose pneumonia on the CT images of a Steno bredanensis (often called "rough-toothed dolphin") that fell ill. Unfortunately, this dolphin did not survive but the CT images obtained have helped in determining treatment plans for other sick marine animals.
One of the Chelonia mydas (often called "green turtle") in the aquarium was in bad shape, but the veterinarians were unable to tell whether it had a lung or visceral organ or peritoneum problem, so they scanned it. From the CT images, it became clear that the turtle had ingested foreign substances that were blocking its intestines. Direct intervention was not needed but the turtle was kept under observation. It lost some weight initially, and then slowly recovered. A follow-up scan one month later revealed that the foreign substances in the intestines had been eliminated and that the turtle would survive.
Most of the scans, about three to five per week, are done as virtual autopsies for research purposes. The veterinarians have



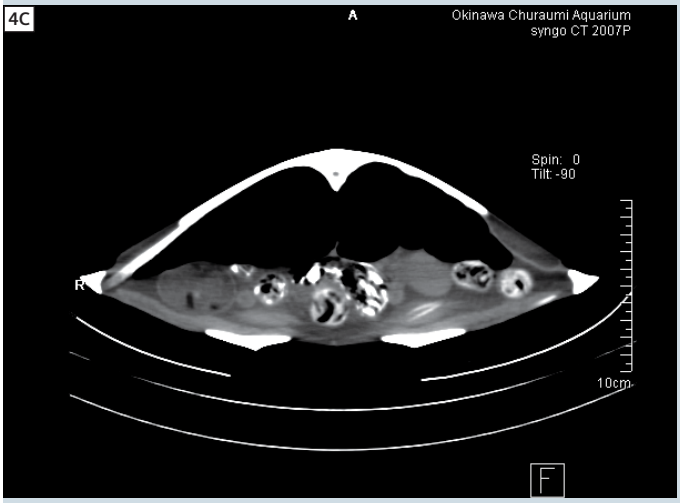
2 Contrast enhanced CT images (VRT) of Chiloscyllium punctatum (often called "brown-banded bamboo shark") showing blood volume.

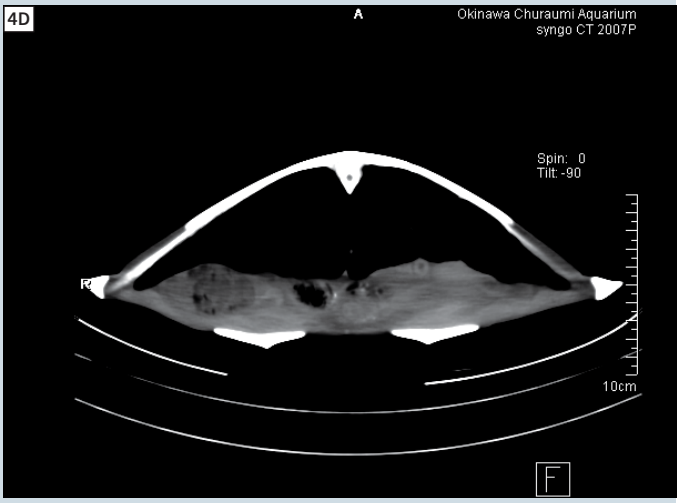


3 A Steno bredanensis (often called "rough-toothed dolphin") diagnosed with pneumonia: positioning of the dolphin (Fig. 3A), axial CT image of the dolphin's lung (Fig. 3B).



4A, B Chelonia mydas (often called "green turtle") in Okinawa Churaumi Aquarium (Fig. 4A). Foreign bodies in turtle's intestines detected with VRT (Fig. 4B).





4C, D Foreign bodies of unknown origin were seen in the turtle's intestines (Fig. 4C). Follow-up scan one month later showed that the ingested substances were eliminated (Fig. 4D).

already assembled an amazing amount of data ranging from dolphin's digestive systems and locations of air leakages when deep-sea fish are brought to the surface, to the morphology of Zoanthids (often called "colonial anemones"). They have presented posters at several Japanese workshops such as last year's Meeting of the Japanese Society of Zoo and Wildlife Medicine. This year they plan to report results at the Spring Meeting of the Japanese Society of Fishery Science and at the Biennial Conference on the Biology of Marine Mammals. A discussion on CT of marine animals has been started.

The team agrees that CT is very useful in the aquarium. "Dissection of marine animals and sketching results take many hours. Additionally organs shift when opening the animals. With CT, we can see the location of bones and organs in their original position at once," Yanagisawa and Hamasaki agrees. "Living marine animals can also be scanned now that we have a CT scanner in-house, which will help determining illnesses and treatment plans," Ueda adds.

Further Information

http://www.kaiyouhaku.com/en/index.html

Spatiotemporal Multi-Band Filter for Reducing Artifacts and Dose

By Rainer Raupach, PhD

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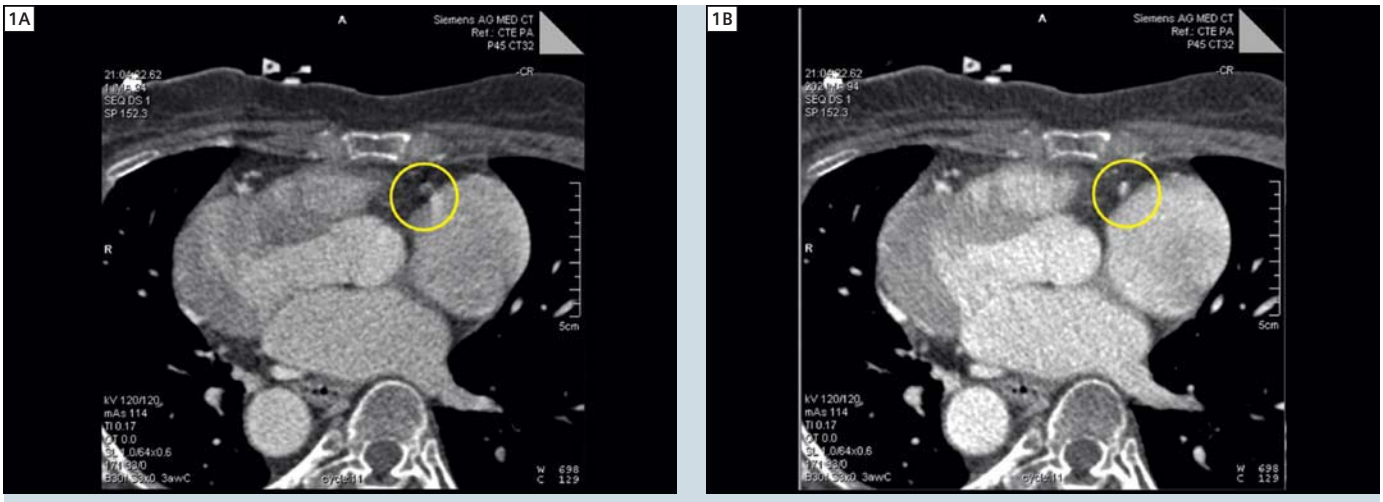
Siemens AG has developed a new algorithm – spatiotemporal Multi-band Filter called 4D Noise Reduction – for use with modern CT scanners when performing routine dynamic CT examinations, such as organ perfusion or 4D CT-Angiography. With 4D Noise Reduction, dose can be drastically reduced without any subsequent loss of image quality. On the other hand, when superior image quality is the highest priority, the spatial resolution of the CT perfusion images can be increased or the reliability of the perfusion parameters improved utilizing the same dose that would be required when not using 4D Noise Reduction, i.e. the "standard" dose.

4D Noise Reduction can be utilized for many investigational purposes: for example, artifacts in cardio CT images can be reduced significantly by maximizing temporal resolution which affects the stability of CT values over a period of time. Therefore, images of unique quality for detecting perfusion-parameters can be achieved. By applying other modifications, visualization of Dual Energy data can be improved and Dual Energy cardio scans can be optimized, offering Dual Energy information as well as delineation of coronary arteries with maximum temporal resolution from a single scan (Fig. 1).



1 Standard Dual Energy cardio mixed image (Fig. 1A) and optimized reconstruction utilizing 4D Noise Reduction (Fig. 1B). Motion artifacts are clearly reduced with simultaneously enhanced contrast.