MULTIMODALITY IMAGE FUSION TO FACILITATE ANATOMIC LOCALIZATION OF ^{99M}TC-PERTECHNETATE UPTAKE IN THE FELINE HEAD

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^{99m}Tc-pertechnetate is excreted in humans by the thyroid glands, gastric mucosa, salivary glands, choroid plexus, and sweat glands. Uptake attributed to the zygomatic and molar salivary glands is used commonly as a reference to assess thyroid uptake and differentiate euthyroid from hyperthyroid cats. However, the exact location and origin of uptake of ^{99m}Tc-pertechnetate in the head during thyroid scintigraphy in cats remains uncertain. The purpose of this study was to localize uptake of ^{99m}Tc-pertechnetate in the head of the cat using multimodality image fusion. Computed tomography (CT), magnetic resonance (MR), and single photon emission tomography (SPECT) imaging were performed successively in two cats during the same anesthesia procedure. Transverse, dorsal, and sagittal images were reconstructed for each modality. Images were rescaled and fused manually. The anatomic location of focal ^{99m}Tc activity in SPECT images was identified in CT and MR images. Four major and four minor focal areas of uptakes were identified in the head in both cats. A rostral conical-shaped activity was identified in the nasal cavity. Two symmetric focal areas of uptakes seen in the soft tissues in the ventro-caudal retro-bulbar region, and rostro-medial to the vertical ramus of the mandible were attributed to zygomatic salivary glands. A central focal activity located ventral and caudal to the zygomatic uptake was located in the nasopharynx and soft palate. Minor symmetric areas of uptake identified in the retromandibular region were attributed to parotid and mandibular salivary glands. Minor symmetric areas of uptake identified in the region of the mandible were attributed to molar salivary glands. No focal area of uptake was identified in the brain. *Veterinary Radiology & Ultrasound, Vol. 47, No. 5, 2006, pp 503–506.*

Key words: cat, CT, image fusion, MR, salivary glands, SPECT, ^{99m}Tc-pertechnetate.

Introduction

Thyroid scintigraphy using ^{99m}Tc-pertechnetate has been used routinely for the diagnosis of feline hyperthyroidism since the mid-1980s.[1] In addition to thyroid, gastric, and renal uptake, concentration in salivary glands, choroid plexus, and sweat glands has been described in humans[2] and animals.[1,3] Uptake attributed to the zygomatic and molar salivary glands is used as a reference to assess thyroid uptake and differentiate euthyroid from hyperthyroid cats.[3] However, due to poor spatial resolution of scintigraphic images, lack of clear anatomical landmarks, and use of planar imaging for thyroid scintigraphy in cats, the exact anatomic location of ^{99m}Tc-pertechnetate uptake in the feline head during thyroid scintigraphy remains speculative.

Multimodality image fusion can overcome the lack of anatomic detail of planar scintigraphic images, single photon emission computed tomography (SPECT), and positon emission tomography (PET).[4,5] The general principle of image fusion is to superimpose images from different but complementary imaging modalities to extract additional information.[4] Image fusion requires spatial alignment of images acquired with different modalities, sometimes at different times, a process referred to as image registration.[5] Our hypothesis was that image fusion using SPECT, computed tomography (CT), and magnetic resonance (MR) images would allow for anatomic localization of ^{99m}Tc-pertechnetate uptake in the head of the cat.

Materials and Methods

CT, MR, and SPECT imaging were performed successively in two cats (a 7-year-old male and a 14-year-old female). Cats were premedicated with medetomidine (Domitor®)* intravenously. Anesthesia was induced and maintained with an IV injection of propofol (Diprivan®).† Cats were in ventral recumbency with the head in extension and thoracic limbs pulled caudally along the thoracic wall for each imaging modality.

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CT images were acquired with a single detector helical CT unit (Philips Secura)‡ using 1-mm-thick transverse slices with a pitch of 1 (120 kV, 120 mA). MR images were acquired with a 0.2 T open magnet§ using a multipurpose small coil and a field of view of 160 × 160 mm. A FLASH 3D (TR = 34 ms, TE = 12 ms) sequence was performed to obtain 1-mm-thick transverse T1-weighted images that were used for multiplanar reconstruction (MPR). In addition, 3-mm-thick transverse T1 (TR 576 ms, TE 26 ms), T2 (TR 4080 ms TE106), and PD (TR 4080 ms TE 26 ms) weighted images were acquired.

SPECT images were acquired starting 30 min after intravenous (IV) injection of 180 Mbq (4.86 mCi) of ^{99m}Tc-Pertechnetate using a single-head gamma camera, Integrated ORBITER Gamma Camera¶ equipped with a low-energy high-resolution parallel-hole collimator. The camera was connected to a dedicated open ICON Workstation computer using Siemens ICON™ computer system software. SPECT images were obtained during a period of 54 min (64 projections at 6° angulation with 50 s acquisition time per projection in a 128 × 128 matrix and zoom factor 1.78). Reconstruction was performed with a Butterworth filter (cutoff 0.40, order 7) without scatter correction. Attenuation correction was performed assuming uniform attenuation with an ellipse drawn around the head. The field of view covered at least the head and neck from the nose to the caudal part of the neck.

Transverse, dorsal, and sagittal images were reconstructed for the three modalities and exported as 8-bit jpeg images. Images were rescaled and fused manually with image software (Adobe Photoshop) using a two-step technique based on the silhouette of the head and maximal focal uptake of ^{99m}Tc. First, the dorsal image having the largest silhouette of the head was selected for the three modalities for preliminary registration. Images were rescaled by selecting a region of interest limited by the tip of the nose and the lateral margin of the head on each side for each modality. The largest matrix of the images from the three modalities (CT) was used as a template to adjust the size of the matrix of the images of the other two modalities. The SPECT image was then added to the CT and MR images and the SPECT image was made 50% transparent, so anatomic details of CT and MR images could be seen through the SPECT image. In a second step, regions of focal uptake of ^{99m}Tc-pertechnetate on the SPECT image were identified and maximal focal uptake was used to select appropriate transverse SPECT images to be fused with corresponding CT and MR images. Maximal uptake was localized using anatomic landmarks on the initial-fused dorsal plane image, and corresponding transverse CT and MR images were selected. The same principle was used to improve registration of the dorsal plane images and to register sagittal images.

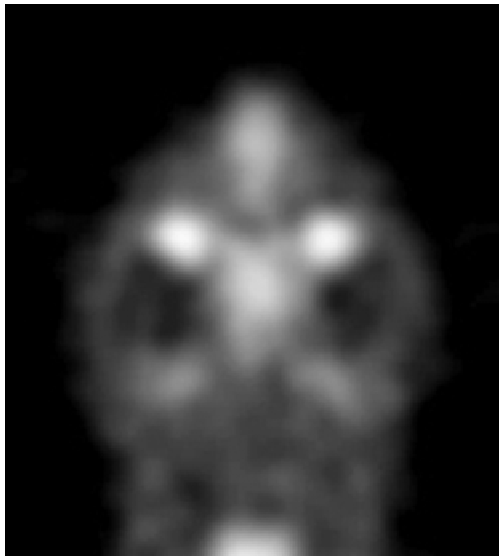

FIG. 1. Dorsal single photon emission computed tomography image. Note four major and two minor regions of focal uptake of ^{99m}Tc-pertechnetate in the head of a cat, in addition to the thyroid uptake.

Fused images in all planes were assessed to identify the position of focal areas of uptake of ^{99m}Tc-pertechnetate in

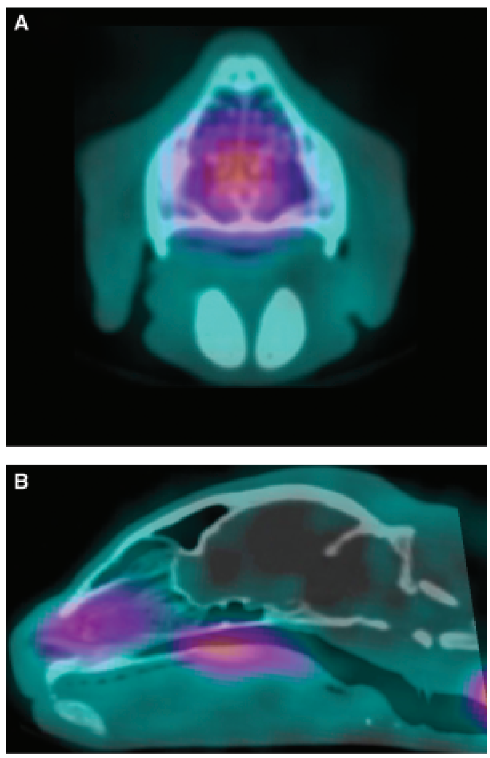

FIG. 2. Transverse (A) and sagittal (B) fused CT and single photon emission computed tomography image. Note focal ^{99m}Tc activity in the nasal cavity and nasopharynx.

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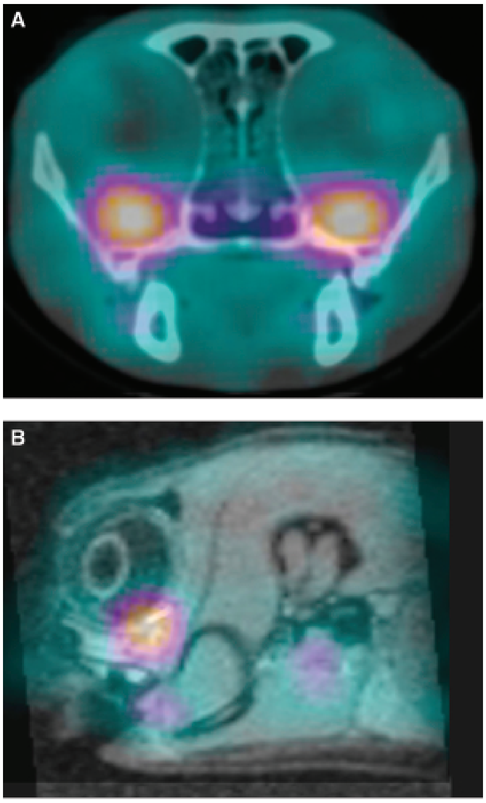

FIG. 3. Transverse fused CT and single photon emission computed tomography image (A) and sagittal used MR and SPECT image (B). Note focal ^{99m}Tc activity in the region of the zygomatic, molar, and parotid (B) salivary glands.

the head. Major uptakes were defined as well-delineated strong accumulation of radiopharmaceuticals. Minor uptakes were defined as a subtle, ill-defined increase in activity compared with the surrounding background.

Results

Four major and four minor focal areas of uptake were identified in the head on SPECT images (Fig. 1). A rostral conical-shaped increased activity was localized in the nasal cavity (Fig. 2). Two symmetric focal uptakes were seen in the soft tissues in the ventro-caudal retro-bulbar region, and rostro-medial to the vertical ramus of the mandible corresponding to the location of the zygomatic salivary glands (Fig. 3). A central focal activity located ventral and caudal to the zygomatic uptake was located in the nasopharynx and soft palate (Fig. 2B). Minor areas of uptake were identified in the retromandibular fossa, just cranial and ventral to the tympanic bullae corresponding to the location of the parotid and mandibular salivary glands (Fig. 4). Minor symmetric focal uptakes were also identified adjacent to the mandible and corresponding to the location of the molar salivary glands (Fig. 3). No focal activity was identified in the brain.

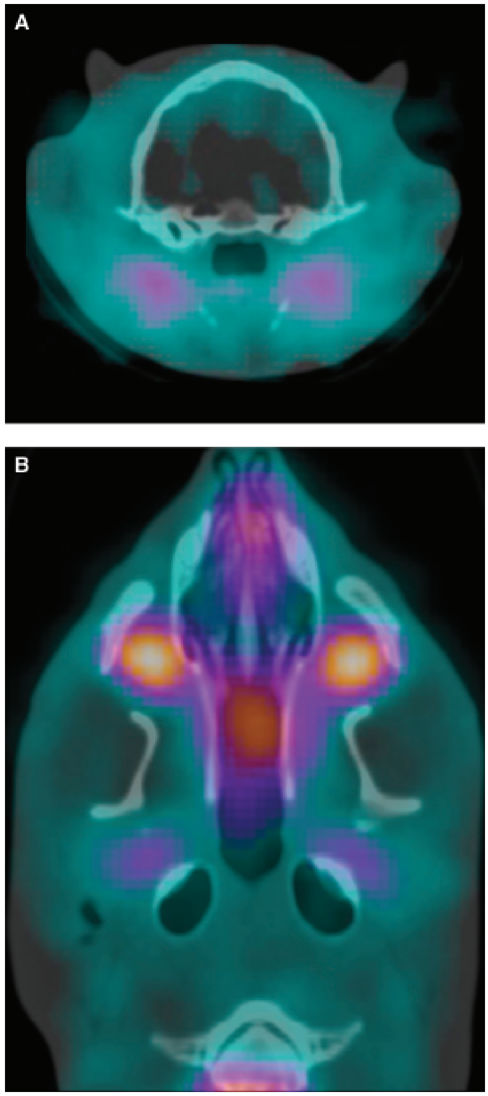

FIG. 4. Transverse (A) and dorsal (B) fused CT and single photon emission computed tomography images. Note focal ^{99m}Tc activity in the region of the parotid and mandibular salivary glands. Note also focal areas of uptake in the region of the zygomatic glands, in the nasopharynx, and in the nasal cavity on the dorsal image (B).

Discussion

Our findings confirm that symmetric focal increased uptake in the head of the cat commonly seen on planar images is due to zygomatic and molar salivary glands. A minor uptake was also present in the region of the parotid and mandibular glands, but the amount of activity in the two regions did not match the relative size of these glands.

Salivary glands in mammals consist of major salivary glands, which are constituted in distinct anatomic entities and minor salivary glands distributed in the oral cavity, oropharynx, and nasopharynx, either diffusely in the oral mucosa or as small glands.[6] Major salivary glands in cats include the parotid, mandibular, sublingual, zygomatic, and molar glands.[7] Parotid and mandibular salivary glands are located close to each other just ventral to the external ear canal.[6] Zygomatic salivary glands are located against the ventral part of the periorbita and surrounded by periorbital fat.[6,8] There are substantial differences between major and minor salivary glands, as well as among minor glands, in the nature and composition of their mucous and serous secretory products[9] that could explain differences in ^{99m}Tc-pertechnetate uptake observed in this study. In cats, zygomatic glands are mainly of a mucous type.[10] Pertechnetate substitutes for Cl^- and enters the acinar cell using the $Na^+/K^+/Cl^-$ co-transport system involved in fluid secretion.[11] In humans, there is a strong correlation between ^{99m}Tc-pertechnetate uptake and major salivary gland flow rates,[2] which can be used to assess salivary secretion abnormalities. High uptake of ^{99m}Tc-pertechnetate by the zygomatic glands in cats may be due to a spontaneous high flow rate and easy response to stimulation, as compared with other salivary glands.[10]

Small molar glands have been described adjacent to the mandibular molar tooth in the cat,[7,12] corresponding to a minor focal uptake noted on fused images. This uptake may be superimposed over the zygomatic uptake on ventral planar images usually acquired during routine thyroid scintigraphy in cats.

Focal uptake in the nasal cavity has not been described in humans or in animals. The nasal cavity contains tubuloacinous glands that closely resemble salivary glands. In cats, these nasal glands are of a mucous type[6] and it can be speculated that they were responsible for nasal uptake identified in this study. Major focal activity in the naso-pharynx may represent accumulation in minor salivary glands located in the soft palate (palatine glands).[6] However, focal accumulation of radioactive mucus from the nasal cavity cannot be excluded. Although focal increased activity in the nasal cavity and in the naso-pharynx is visible on planar ventral images, their exact origin has not yet been recognized. The uptake in the nasal cavity may have been mistaken for salivary activity in the oral cavity after excretion from the zygomatic glands. The centrally located uptake in the naso-pharynx has been attributed previously to choroid plexus on planar images.

Focal uptake was not found in the region of the choroid plexus, as expected from the literature. Choroid plexus uptake of ^{99m}Tc-Pertechnetate has been documented in rabbits[13] and in humans[14] where it has been used for the diagnosis of choroid plexus papillomas.[15] Choroid plexus uptake has not been documented in cats, although it has been reported as such, erroneously extrapolated from experimental and clinical data in humans.[1]

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