radioiodine concentration (215 Bq/μl) was reached by 1 hr and was presumably related to peak plasma concentration (*10*). A fraction of radioiodine secreted in tears accumulated behind the prosthetic eye, as shown in the 24-hr image, and another fraction drained in the patent nasolacrimal duct accounted for some of the nasal activity. The status of the patient, being hypothyroid or hyperthyroid (on thyroxine suppression), did not appear to significantly affect radioiodine accumulation in the orbit (Fig. 1) (*3*). This is in agreement with a previous study on radioiodine uptake by extrathyroidal tissues that did not demonstrate any response to TSH stimulation (*2*).

We estimated that about 0.01% of the administered radioiodine dose is secreted in tears (in each eye) during the first 4 hr. The clinical significance on the function of the lacrimal gland of radioiodine secretion in tears, when repeated large doses of ^{131}I are given, or on the lens when the nasolacrimal ducts are blocked, is not known and needs further study. It is of interest that the parotid and lacrimal gland functions were reduced in a thyroid cancer patient who had undergone thyroidectomy and treatment with radioiodine (*11*). However, it was suggested that hormonal and metabolic derangements, rather than the direct effect of ^{131}I on the glands, were responsible for the glandular dysfunction.

CONCLUSION

Although the mechanism(s) of radioiodine lacrimal uptake remain(s) unclear, it is unrelated to TSH levels. Further studies are needed to calculate the amount of radioiodine secretion in patients with normal thyroid glands and eyes and to calculate the radiation dose delivered to the lacrimal glands as well as to explore the prevalence of dry eye in thyroid cancer patients who have received multiple high doses of radioiodine treatments.

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Gallium-67-Citrate Scanning of Renal Parenchymal Malacoplakia

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The purpose of this article is to review the potential role of nuclear medicine scanning, especially with ^{67}Ga, in the presumptive diagnosis and clinical management of patients with renal parenchymal malacoplakia (RPMP), a rare disease associated with coliform bacterial infection of the kidney and characterized by chronic unresolving inflammatory infiltrates containing von Hansemann macrophages in the renal parenchyma. **Methods:** Published cases of RPMP were collected from the archival literature by searching the MEDLINE database and by reviewing bibliographic references contained in articles on malacoplakia. Data on the clinical features and radiographic evaluation of patients with RPMP were extracted from the clinical case reports. **Results:** Forty-three cases of RPMP published over the past 20 yr were identified. Ten of the 43 patients (23%) had ^{67}Ga scanning as a component of their diagnostic evaluation. In all 10 patients, renal uptake of ^{67}Ga was classified as intense. Two of those 10 patients had serial ^{67}Ga scanning performed to assess response to antibiotic treatment; both patients exhibited decreased uptake or complete resolution of abnormal renal uptake over time, a finding also exhibited by our patient. **Conclusion:** Intense renal uptake of ^{67}Ga, typically in the clinical setting of fever, progressive renal failure and nephromegaly, strongly supports a diagnosis of RPMP. In those patients receiving prolonged antimicrobial therapy for RPMP, resolution of abnormal ^{67}Ga uptake over time may provide an objective endpoint for treatment.

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Malacoplakia, a rare inflammatory disorder of uncertain etiology associated with coliform bacterial infection, most commonly involves the genitourinary tract, particularly the bladder and ureters (*1–4*). Renal parenchymal malacoplakia (RPMP), a severe form of genitourinary tract malacoplakia, frequently mimics pyelonephritis and may be quite difficult to diagnose, especially since ultrasound and CT often demonstrate only nephromegaly (*2–6*). The diagnostic test of choice for RPMP is renal biopsy with histopathological identification of pathognomonic Michaelis-Gutmann bodies within von Hansemann macrophages (*2,3*). However, the decision to pursue renal biopsy, a potentially morbid procedure, is often difficult. A noninvasive diagnostic study that might predict which patients with unresolved pyelonephritis should be biopsied to exclude RPMP would be clinically useful.

Optimal therapy for RPMP has not been well defined. Although surgical resection was previously the preferred management for RPMP (*2,3,7*), recent literature emphasizes the emerging role of prolonged antimicrobial therapy in management (*2,3,8*). The duration of effective therapy for RPMP has varied from weeks to months with relapse after inadequate treatment a well-recognized problem (*2–5*). Some authors have

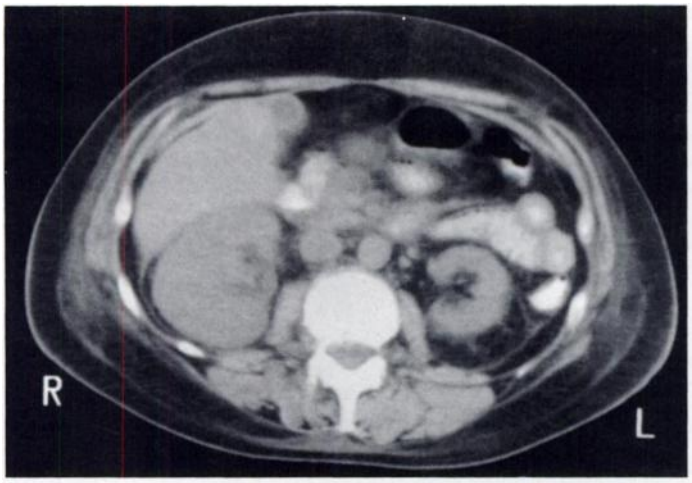

FIGURE 1. CT of abdomen demonstrating marked nephromegaly of right kidney compared to left.

advocated that clinical parameters (e.g., fever, sedimentation rate, etc.) be monitored serially to determine the therapeutic endpoint while others have used serial renal biopsies to decide when to discontinue therapy (*9,10*). Since RPMP is an inflammatory process, we chose to investigate the use of ^{67}Ga-citrate scanning in both diagnostic and therapeutic considerations.

CASE REPORT

A 50-yr-old woman was admitted to the North Carolina Baptist Hospital with a 4-day history of fever to 38.9°C, chills, myalgias, nausea, vomiting and orthostatic dizziness. Her blood pressure was 92/62 mm Hg and her mucus membranes were dry. Her abdominal examination revealed no masses or costovertebral angle tenderness. Laboratory studies were significant for sodium, 121 mEq/liter, blood urea nitrogen, 58 mg/dl, and serum creatinine, 4.4 mg/dl (baseline creatinine 1.4 mg/dl). The leukocyte count was 14,500/mm^3 with the hemoglobin 10.1 gm/dl and the platelet count 58,000/mm^3.

Admission cultures of blood and urine grew *Escherichia coli*. Despite appropriate antibiotic therapy, fevers persisted. A CT scan of the abdomen and pelvis revealed a markedly enlarged right kidney as compared to the left (Fig. 1). Ultrasonography confirmed nephromegaly on the right, with increased echogenicity throughout the enlarged kidney. An ^{111}In-white blood cell (WBC) scan revealed increased uptake in the small intestine and photopenic lesions in the right pelvis and lumbar spine but no abnormal activity in the kidney. A ^{67}Ga scan was performed. Planar images were obtained at 24, 48 and 120 hr plus SPECT at 48 hr. These clearly demonstrated markedly increased uptake throughout the right kidney and in the upper pole of the left kidney (Fig. 2A).

The patient was discharged home on ciprofloxacin 500 mg orally twice a day for ongoing therapy of presumed slowly resolving pyelonephritis. On follow-up, she was noted to have persistent fevers, a creatinine of 2.4 mg/dl, and an erythrocyte sedimentation rate (ESR) of 107 mm/hr. A CT-guided biopsy of the right kidney was performed. Histopathology demonstrated an extensive inflammatory infiltrate consisting of macrophages and plasmacytes that destroyed the normal renal architecture. Both periodic acid–Schiff and von Kossa's stains were positive for Michaelis-Gutmann granules, thus confirming a diagnosis of malacoplakia. In view of the biopsy findings, treatment with ciprofloxacin was continued but rifampin 300 mg orally twice a day and ascorbic acid 500 mg orally twice a day were added. A repeat ^{67}Ga scan 2 mo after discharge showed resolution of uptake in the upper pole of the left kidney and diminished, but still present, uptake in the right kidney (Fig. 2B). The serum creatinine was 2.1 mg/dl and the ESR 37 mm/hr at that time. Five months after discharge, the patient was much improved clinically with return of her ESR to normal and decline in her serum creatinine to <2.0 mg/dl. When a final ^{67}Ga scan revealed no abnormal renal uptake (Fig. 2C), ciprofloxacin was discontinued. The patient has remained well with no evidence of relapse of her RPMP. Her most recent serum creatinine was 2.3 mg/dl with an ESR of 11 mm/hr.

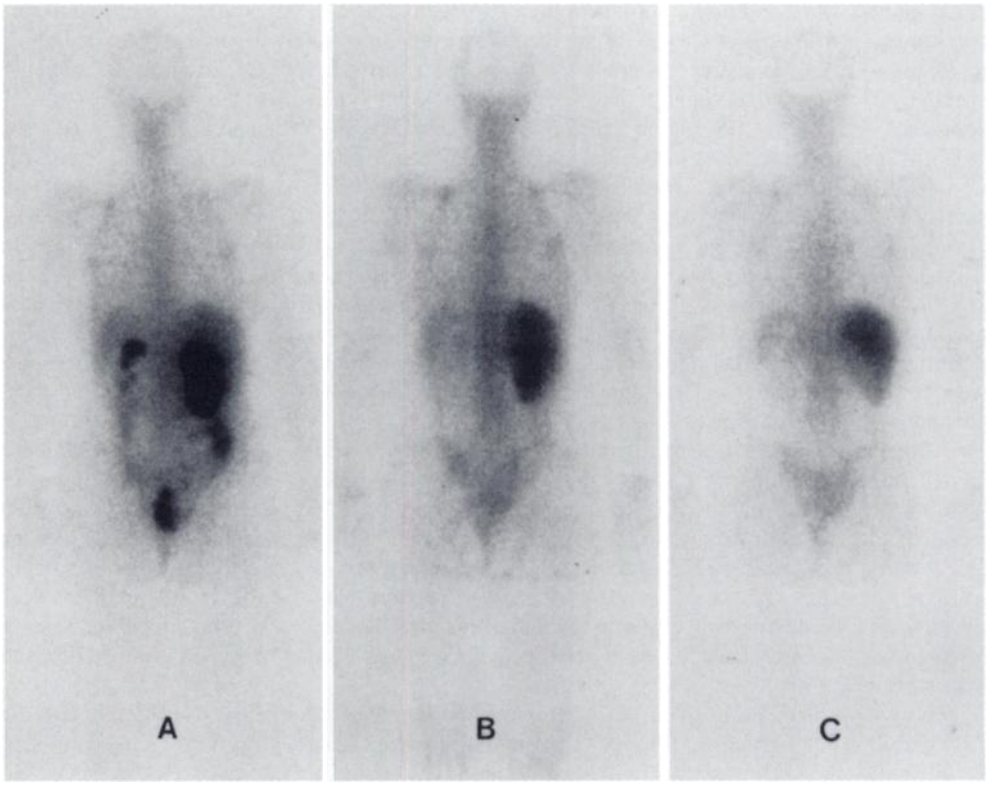

FIGURE 2. Posterior whole-body views from gallium scans. (A) Scan performed on Nov. 28, 1993 shows markedly increased activity throughout right kidney and in region of upper pole of left kidney. The remainder of activity in abdomen is thought to be due to normal colonic excretion. (B) Scan performed on Dec. 30, 1993 shows left kidney appearing normal with considerable decrease in abnormal right renal activity. (C) Scan performed on Mar. 23, 1994 shows no abnormal renal accumulation.

TABLE 1
Diagnostic Gallium-67 Scanning in Renal Parenchymal Malacoplakia

Reference	Age (yr)	Sex	Findings on ^{67}Ga Scanning	Used in Follow-Up?
20	51	M	Increased activity in the kidneys, especially on the right	No
22	51	M	Increased uptake in both kidneys	No
23	25	F	Scan was performed during the postoperative phase, revealing positive uptake in the left renal bed and in the right kidney	No
27	11	F	Diffusely increased bilateral renal uptake with renal enlargement also noted	No
29	56	M	Intense uptake of ^{67}Ga	6 and 12 mo gallium: normal uptake
30	6 mo	M	Strikingly diffuse uptake in both kidneys suggestive of multiple microabscesses or mononuclear cell infiltrate	
33	69	M	Markedly increased uptake, which was interpreted as an interstitial nephritis	No
7	49	F	Intense ^{67}Ga accumulation in the parenchyma of both kidneys that was thought to be consistent with parenchymal inflammation such as severe glomerulonephritis, interstitial nephritis or vasculitis	8 wk gallium: marked interval decrease in uptake
35	61	M	Marked uptake in both kidneys	No
2	56	F	Marked and diffuse uptake of tracer in the right kidney, consistent with an inflammatory process	No
Current	50	F	Marked uptake in the right kidney and upper pole of the left kidney	2 mo: interval decrease in uptake; 5 mo: normal uptake

REVIEW OF THE LITERATURE

Approximately 62 cases of malacoplakia with documented renal involvement have been reported in the world's literature (*2*). Based on information provided in the case reports, radiographic imaging studies were used in the diagnosis and serial evaluation of 43 of these patients (*2,3,5–7,9–35*).

Radiographic Diagnosis

Most patients with RPMP (34/43, 79%) had standard genitourinary radiologic diagnostic techniques such as intravenous pyelography (IVP) or retrograde pyelography (*2,6,10,12–19,21–24,26–31,33,34*). The majority of these studies were interpreted as normal with occasional patients exhibiting nonspecific findings. When abnormalities were described, nonfunctioning or poorly functioning kidneys and/or nephromegaly were the most usual findings (*6,14,18,28*). Thus, IVP and retrograde urography rarely provided specific information that suggested a diagnosis of possible malacoplakia.

Ultrasonography was used in the evaluation of 22 of the 43 cases (*2,3,5–7,9,16,20,21,23,24,26,28–30,32–35*). The majority of these studies revealed nephromegaly. Other findings included distinct hypoechoic regions (*26*) and increased parenchymal echoes (*6,30*). Compression and distortion of the calyces were also described (*16,28*). In at least one case of biopsy-proven RPMP, an ultrasound examination was normal (*32*). Although it is a sensitive study for detecting changes in renal architecture and size, ultrasonography was less accurate in demonstrating findings associated with renal parenchymal inflammation.

CT of the abdomen was performed on only 11 patients with RPMP. Nine of 11 (82%) CT scans were interpreted as abnormal, with nephromegaly and parenchymal inhomogeneity being the most commonly described abnormalities (*2,3,7,22,25,26,28,30,33,34*). One of the earliest documented CT scans in a patient with proven RPMP revealed an extensive tumefactive process (*29*). As was true for ultrasonography, CT scanning was a sensitive technique for demonstrating nephromegaly but otherwise provided no specific information to suggest a diagnosis of RPMP.

Ten patients with RPMP had ^{67}Ga scanning (*2,7,20,22,23,27,29,30,33,35*). The findings in these cases are summarized in Table 1. All studies demonstrated abnormal accumulation of ^{67}Ga in the involved kidney(s), with the uptake described as "increased," "intense," "strikingly diffuse," "markedly increased" and "marked" (*20,29,30,33,35*). The case diagnosed at our institution was similar, with the ^{67}Ga scan revealing markedly increased uptake in the right kidney and the upper pole of the left kidney.

Serial Evaluation and Determination of Therapeutic Endpoints

Of the 32 patients for whom follow-up data were available, information on serial radiographic studies performed to evaluate response to therapy was provided for only 7 patients. In an early report from 1977 (*16*), an intravenous urogram obtained 4 mo post-therapy (duration of treatment not specified) revealed kidneys of normal size that contrasted sharply with the marked nephromegaly that had been present before therapy. Renal ultrasonography was used in 2 patients as a follow-up study to assess response to therapy (*5,26*). In 1 patient, nephromegaly had resolved, whereas renal size was described as "decreased" in the other. Two more recent reports used serial abdominal CT scans to demonstrate interval radiographic improvement with therapy as judged by resolution of nephromegaly (*2,3*). Two cases were evaluated with ^{67}Ga scanning to follow response to antibiotic treatment (Table 1) (*7,30*). An interval decrease in uptake was found in 1 patient and complete resolution of abnormal renal uptake in the other. Our own patient was followed with serial ^{67}Ga scans that revealed resolution of renal inflammation over time (Fig. 2).

DISCUSSION

With the recent identification of effective therapies for the medical management of malacoplakia (*2,3,8*), prompt and accurate diagnosis of RPMP has assumed increasing importance. Likewise, clearer delineation of an appropriate endpoint for therapy also has become an important issue since prolonged courses of treatment seem to be warranted yet the duration of No significant difference between pre-tx and post-tx.therapy may vary from patient to patient depending on the extent and severity of disease.

Intense uptake of radionuclide is the hallmark of inflammation with ^{67}Ga scanning (*36*). Approximately 10%–20% of the administered dose of ^{67}Ga is excreted by the kidneys and faint

renal activity is commonly seen, especially on images obtained earlier than 24 hr postinfusion. However, prominent renal uptake of ^{67}Ga persisting at 48 and 72 hr should be viewed as abnormal. Intense and persistent renal parenchymal uptake of ^{67}Ga should lead to a differential diagnosis that includes diffuse pyelonephritis, interstitial nephritis, vasculitis, amyloidosis, renal lymphoma and RPMP (*37*). In regard to RPMP, our review of case reports over the past 20 yr indicates that ^{67}Ga scanning is consistently and intensely positive in patients with renal malacoplakia. Thus, ^{67}Ga scanning may represent a sensitive radiographic tool for identifying inflammation within the kidney, the first step in considering a diagnosis of RPMP. Once a diagnosis of RPMP is considered, the decision to proceed with renal biopsy is then often straightforward.

The sensitivity of ^{67}Ga scanning for identifying the inflammation associated with RPMP compared to other nuclear medicine scanning modalities (e.g., ^{111}In WBCs, renal cortical imaging agents such as ^{99m}Tc-dimercaptosuccinic acid (DMSA) or ^{99m}Tc-gluceptate) is currently unknown. Our patient had an ^{111}In-WBC scan that was negative before the abnormal ^{67}Ga scan. Although no other cases were identified in our literature review that had ^{111}In-WBC scanning, two patients had ^{99m}Tc-DMSA scans that revealed decreased uptake (*14,35*).

Although emerging data support a role for antibiotics in the management of RPMP (*3,7,35*), the exact duration of therapy needed to achieve a successful outcome is undefined. Most recently reported patients that have been managed effectively with antibiotic therapy have received prolonged courses of treatment ranging between 6 wk and 4 mo (*2,3,7,35*). Parameters used to define the endpoint of therapy have varied from clinical features (e.g., fever, abdominal pain) to simple laboratory studies (e.g., resolution of pyuria, normalization of the ESR) (*9,35*). In some cases, follow-up renal ultrasonography or abdominal CT scanning to evaluate resolution of nephromegaly have been used to assist in determining the therapeutic endpoint (*2,3,5,26*). However, none of these parameters may accurately or sensitively reflect whether or not renal parenchymal inflammation has totally resolved.

In our patient, serial ^{67}Ga scans revealed progressive diminution of uptake over time, suggesting that renal inflammation was subsiding in response to therapy. When our patient's ^{67}Ga scan was judged to be normal, we concluded that an appropriate therapeutic endpoint had been reached and discontinued antibiotic therapy. Thus far, she has not demonstrated any clinical findings that might suggest relapsing RPMP. Similarly, in two other cases reported in the literature (*7,30*), follow-up ^{67}Ga scans revealed improvement over time. However, in neither of those cases were the ^{67}Ga scan results used to define the endpoint of therapy.

CONCLUSION

In summary, RPMP is a chronic inflammatory disease manifested clinically by persistent fevers, pyuria and progressive renal failure. Intense uptake of ^{67}Ga in the involved kidney(s), typically in the setting of nephromegaly, strongly supports a diagnosis of RPMP and should lead to consideration of diagnostic renal biopsy. In those patients receiving prolonged antimicrobial therapy for RPMP, the appropriate endpoint of treatment may be best defined by resolution of increased renal parenchymal uptake of ^{67}Ga. Additional reported experience with this approach will be required to validate its clinical applicability.

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