CASE RECORDS of the MASSACHUSETTS GENERAL HOSPITAL

Case 29-2024: A 47-Year-Old Man with Confusion and Kidney Failure

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PRESENTATION OF CASE

Dr. Suellen S. Li (Medicine): A 47-year-old man was admitted to this hospital because of confusion and acute kidney failure.

The patient had been well until 6 days before the current admission, when fatigue and myalgias developed. During the subsequent 2 days, he continued to report to his job at a restaurant. Four days before this admission, the patient's coworkers noticed that he was mildly confused. On the day of this admission, the confusion markedly increased, and new word-finding difficulties and garbled speech developed. Emergency medical services were called, and the patient was brought to the emergency department of this hospital.

On evaluation in the emergency department, the patient was not able to participate fully in the interview or a review of systems because of confusion, but he described feeling hot and short of breath. He had not mentioned any recent cough, nausea, vomiting, diarrhea, or headache to his family or coworkers. He had no known recent falls, trauma, travel, or sick contacts.

Additional history was obtained from the patient's family. He had no known medical problems or drug allergies. He used no prescription medications but took ginseng extract and burdock root supplements. He lived in an urban area of New England with a friend and no pets in a former factory that had been converted into apartments. The patient smoked marijuana occasionally and had smoked cigarettes as a teenager. He drank alcohol infrequently and did not use illicit drugs. His sister had Sjögren's syndrome, nemaline myopathy, cardiomyopathy, Fanconi's anemia, and renal tubular acidosis. His parents were healthy.

On examination, the temporal temperature was 35.8°C, the blood pressure 142/78 mm Hg, the pulse 114 beats per minute, the respiratory rate 30 breaths per minute, and the oxygen saturation 96% while the patient was breathing ambient air. The patient appeared anxious. He was alert and oriented; however, when he was asked a question, he often needed clarification and was slow to answer. He could not recite the days of the week backward and had difficulty following complex commands. His face was symmetric, and no dysarthria was noted. Cranial-nerve function, muscle tone and strength, sensation, proprioception, deep-tendon reflexes,

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and gait were normal. He did not have photophobia. The mucous membranes were moist, and the neck was supple. There was no jugular venous distention. The heart sounds were normal, and the lungs were clear on auscultation. The abdomen was nontender, and there was no hepatosplenomegaly. He had no leg swelling or rash.

The patient had a white-cell count of 13,270 per microliter (reference range, 4500 to 11,000). The blood urea nitrogen level was 117 mg per deciliter (41.8 mmol per liter; reference range, 8 to 25 mg per deciliter [2.9 to 8.9 mmol per liter]), the creatinine level 13.0 mg per deciliter (1149 μmol per liter; reference range, 0.6 to 1.5 mg per deciliter [53 to 133 μmol per liter]), and the creatine kinase level 28,581 U per liter (reference range, 60 to 400). He had hyponatremia, hyperkalemia, and acidosis, as well as elevated blood levels of aspartate aminotransferase and alanine aminotransferase. Laboratory test results are shown in Table 1. A comprehensive urine toxicology screen was negative, as was a serum toxicology screen for acetaminophen, salicylates, ethanol, and tricyclic antidepressants. Nucleic acid testing of a specimen obtained from the nasopharynx was negative for severe acute respiratory syndrome coronavirus 2, adenovirus, human metapneumovirus, influenza virus types A and B, parainfluenza virus types 1 through 4, and respiratory syncytial virus, as well as *Bordetella pertussis*, *B. parapertussis*, *Chlamydia pneumoniae*, and *Mycoplasma pneumoniae*.

Dr. Melissa C. Price: Imaging studies were obtained. Radiography of the chest revealed an opacity in the right lower lobe (Fig. 1A). Computed tomography (CT) of the head was normal.

Dr. Li: Intravenous dextrose, insulin, calcium gluconate, and fluids were administered, and treatment with intravenous ceftriaxone and azithro-

Table 1. Laboratory Data.*

Variable	Reference Range, Adults†	On Admission
Blood		
White-cell count (per μl)	4500–13,000	13,270
Differential count (per μl)		
Neutrophils	1800–7700	12,560
Lymphocytes	1000–4800	240
Monocytes	200–1200	230
Eosinophils	0–900	10
Basophils	0–300	60
Immature granulocytes	0–100	170
Hematocrit (%)	36.0–46.0	46.7
Hemoglobin (g/dl)	12.0–16.0	16.5
Platelet count (per μl)	150,000–450,000	191,000
Sodium (mmol/liter)	135–145	125
Potassium (mmol/liter)	3.4–5.0	6.0
Chloride (mmol/liter)	98–108	75
Carbon dioxide (mmol/liter)	23–32	9
Urea nitrogen (mg/dl)	8–25	117
Creatinine (mg/dl)	0.6–1.5	13.0
Glucose (mg/dl)	70–110	184
Anion gap (mmol/liter)	3–17	41
Magnesium (mg/dl)	1.7–2.4	3.7
Calcium (mg/dl)	8.5–10.5	8.0
Albumin (g/dl)	3.3–5.0	3.7
Aspartate aminotransferase (U/liter)	9–32	418
Alanine aminotransferase (U/liter)	7–33	1272

Table 1. (Continued.)

Variable	Reference Range, Adults†	On Admission
Alkaline phosphatase (U/liter)	30–100	74
Total bilirubin (mg/dl)	0.0–1.0	0.7
Lactic acid (mmol/liter)	0.5–2.0	2.3
Creatine kinase (U/liter)	60–400	28,581
Lactate dehydrogenase (U/liter)	110–210	1334
C-reactive protein (mg/liter)	0.0–8.0	220.4
Erythrocyte sedimentation rate (mm/hr)	0–13	69
Ferritin (μg/liter)	20–300	5064
D-Dimer (ng/ml)	0–500	>10,000
Prothrombin time (sec)	11.5–14.5	16.2
Prothrombin-time international normalized ratio	0.9–1.1	1.3
Venous blood gases		
pH	7.30–7.40	7.26
Partial pressure of carbon dioxide (mm Hg)	38–50	27
Partial pressure of oxygen (mm Hg)	35–50	29
Urine		
Bilirubin	Negative	Negative
Urobilinogen	Negative	Negative
Blood	Negative	3+
Glucose	Negative	1+
Ketones	Negative	Negative
Leukocyte esterase	Negative	Negative
Nitrite	Negative	Negative
pH	5.0–9.0	5.5
Specific gravity	1.001–1.035	1.014
Protein	Negative	2+
Red cells (per high-power field)	0–2	10–20
White cells (per high-power field)	0–10	10–20

* To convert the values for urea nitrogen to millimoles per liter, multiply by 0.357. To convert the values for creatinine to micromoles per liter, multiply by 88.4. To convert the values for glucose to millimoles per liter, multiply by 0.05551. To convert the values for magnesium to millimoles per liter, multiply by 0.4114. To convert the values for calcium to millimoles per liter, multiply by 0.250. To convert the values for bilirubin to micromoles per liter, multiply by 17.1. To convert the values for lactic acid to milligrams per deciliter, divide by 0.1110.

† Reference values are affected by many variables, including the patient population and the laboratory methods used. The ranges used at Massachusetts General Hospital are for adults who are not pregnant and do not have medical conditions that could affect the results. They may therefore not be appropriate for all patients.

mycin was started. A Foley catheter was placed, and oliguria was noted. The patient was admitted to this hospital.

Three hours after the patient's arrival, the temporal temperature increased to 38.2°C. The respiratory rate increased to 45 breaths per minute, and the oxygen saturation decreased to 89% while the patient was breathing ambient air. Supplemental oxygen was delivered through a nasal cannula at a rate of 6 liters per minute, and the oxygen saturation increased to 98%.

Dr. Price: CT of the chest, abdomen, and pelvis, performed without the administration of intravenous contrast material, showed consolidation in the right lower lobe with minimal adjacent ground-glass opacity (Fig. 1B). There was no evidence of lymphadenopathy.

Dr. Li: A diagnostic test was performed.

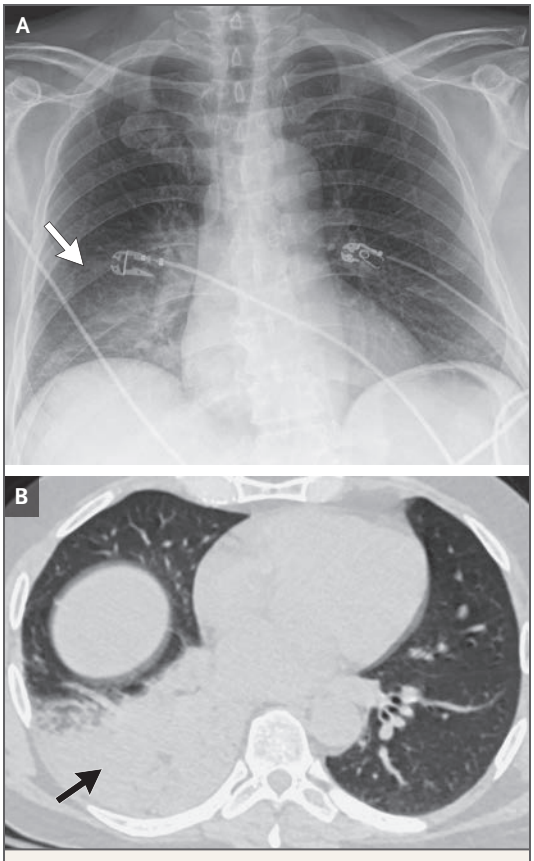

Figure 1. Imaging Studies of the Chest.

Imaging studies were obtained at the time of admission. An anteroposterior chest radiograph (Panel A) shows an opacity in the right lower lobe (arrow). An axial image obtained on CT of the chest, abdomen, and pelvis (Panel B), performed without the administration of intravenous contrast material, shows consolidation in the right lower lobe with minimal adjacent ground-glass opacity (arrow). He had no lymphadenopathy.

DIFFERENTIAL DIAGNOSIS

Dr. Sachin J. Shah: This 47-year-old man presented with an acute illness that was characterized by nontraumatic, nonexertional rhabdomyolysis, oliguric kidney failure, lung consolidation with systemic inflammation, encephalopathy, and liver injury. It is notable that he had a family history of nemaline myopathy, and his exposures included the use of dietary supplements, residence in a converted factory, and smoking marijuana.

To build the differential diagnosis, I will attempt to distinguish the "prime movers" in this case (findings that indicate the mechanisms driving this patient's presentation) from the consequences of the prime movers. The presentation suggests two possible prime movers: nontraumatic, nonexertional rhabdomyolysis and lung consolidation with systemic inflammation. The other conditions that were noted on presentation — oliguric kidney failure, anion-gap and non–anion-gap metabolic acidosis, liver injury, and encephalopathy — can all be reasonably classified as end-organ injuries resulting from the primary process.

Of the two possible prime movers, nontraumatic, nonexertional rhabdomyolysis will be the focus of my differential diagnosis. I purposely used a noncommittal description for the second possible prime mover: lung consolidation with systemic inflammation. I am reluctant to use the more specific label of pneumonia because the case presentation does not fit my theoretical illness script for pneumonia. In cases of classic community-acquired pneumonia, I would expect the patient to be an older adult with coexisting conditions who presents with some combination of fever, dyspnea, cough, and chest pain. In this case, the patient is a younger adult whose primary symptoms include fatigue, myalgias, and confusion. As a result, I will build my differential diagnosis around nontraumatic, nonexertional rhabdomyolysis, while keeping in mind that the ultimate diagnosis must link the two prime movers and the secondary conditions.

NONTRAUMATIC, NONEXERTIONAL RHABDOMYOLYSIS

This patient's history does not support trauma or exertion as the cause of rhabdomyolysis, thus limiting the differential diagnosis. There are several causes of nontraumatic, nonexertional rhabdomyolysis.[1,2] The history and results of the laboratory evaluation do not support the use of alcohol or medications (e.g., statins or stimulants), electrolyte abnormalities, or endocrinopathies as the cause in this patient's case. Therefore, I will discuss toxin exposure, inflammatory myopathies, and infectious causes of nontraumatic, nonexertional rhabdomyolysis, any of which could be compatible with this patient's presentation. Congenital myopathies are not typically thought to cause rhabdomyolysis in adults; however, the family history of nemaline myopathy warrants review.

NEMALINE MYOPATHY

Nemaline myopathy is a rare genetic disorder caused by genetic variants that affect the proteins of the thin filament of the skeletal muscle sarcomere.[3] Most patients have congenital disease and

present at birth with normal to mildly elevated creatine kinase levels and symmetric generalized weakness that is disproportionately bulbar and axial.[4] Adult-onset disease is possible and usually manifests as subacute, slowly evolving atrophy and weakness, most often occurring with normal creatine kinase levels.[5] In a case series involving 76 patients with late-onset nemaline myopathy, half the patients had monoclonal gammopathy of unknown significance.[6] The mismatching case features and time course make nemaline myopathy unlikely to be the diagnosis in this case.

TOXINS, POISONS, AND DRUGS

Exposure to toxins and poisons can cause rhabdomyolysis. Heavy metals and venom have been reported to cause rhabdomyolysis, as has Haff disease, which is associated with the consumption of fish. Use of supplements, such as creatine, ephedra, and caffeine, has been described in cases of rhabdomyolysis and is relevant in this case. Patients with rhabdomyolysis who took these supplements often had other factors to consider, such as exertion, heat exposure, or the use of prescription medications. This patient reported taking ginseng and burdock root supplements, which have not been associated with rhabdomyolysis. However, because of limited regulatory oversight, it is often hard to discern the ingredients in many supplements.

Many prescription medications and recreational drugs have been identified as possible inducers of rhabdomyolysis. However, in this case, the patient did not report using prescription medications, and the lack of case reports suggests that the use of marijuana does not result in rhabdomyolysis.

INFLAMMATORY MYOPATHY

Inflammatory myopathy warrants consideration, given this patient's family history of Sjögren's syndrome, which is characterized by lacrimal and salivary gland inflammation. Pulmonary manifestations include bronchiolitis, cystic lung disease, and fibrotic disease; lung consolidation is not a typical radiographic finding. Muscular manifestations of Sjögren's syndrome are rare and usually progress over a subacute time course.

Myopathy occurs more commonly with other rheumatologic illnesses, including dermatomyositis, antisynthetase syndrome, polymyositis, immune-mediated necrotizing myopathy, and inclusion-body myositis. Patients typically present with subacute, progressive muscle weakness. These diagnoses are often supported by findings on examination (e.g., heliotrope rash), pertinent positive details in the case history (e.g., Raynaud's phenomenon or inflammatory arthritis), elevated levels of creatine kinase and lactate dehydrogenase, and the presence of disease-specific markers (e.g., antibodies against aminoacyl–transfer RNA [tRNA] synthetases). Nerve-conduction studies, electromyography, and biopsy are performed to make a definitive diagnosis. Dermatomyositis, antisynthetase syndrome, and polymyositis can result in pulmonary manifestations; however, imaging findings commonly include bronchiectasis, ground-glass opacities, and reticulation. Organizing pneumonia is a possibility that would explain the lung consolidation seen on this patient's chest CT. Although inflammatory myopathy cannot be completely ruled out, the acute onset and severity of the presentation (i.e., acute kidney failure) suggest another cause.

INFECTION

Multiple viral, fungal, and bacterial infections can cause rhabdomyolysis. The combined presence of rhabdomyolysis and lung consolidation, along with the acute onset and severity of this patient's presentation, is compatible with a diagnosis of influenza. Influenza is unlikely, given the negative nucleic acid amplification test (NAAT); however, when the pretest probability is high, it is prudent to consider a false negative test. False negative nasopharyngeal NAATs have been observed with some influenza subtypes that have a predilection for the lower respiratory tract, such as H1N1 and H5N1.[7]

Acute or chronic human immunodeficiency virus type 1 (HIV-1) infection can result in rhabdomyolysis in rare cases.[8] HIV infection should be considered in this case, given its variable presentation and the possibility of concurrent pneumonia in patients with untreated HIV. Although the acute onset of the presentation argues against HIV infection as the underlying diagnosis, the patient should be tested for HIV.

Aspergillus infection can cause rhabdomyolysis and pulmonary involvement. It is an uncommon infection that can be difficult to diagnose. Typical presenting signs and symptoms include fever, chest pain, dyspnea, cough, and hemoptysis. When considering the diagnosis of aspergillus infection, it is important to consider host factors that confer a predisposition to the infection. People

at risk include those who have diseases or take medications that result in immunocompromise or have structural lung disease. With compatible host factors, the use of marijuana would be a relevant exposure. In addition, the tempo of the disease process in this patient is more rapid than would be expected with an aspergillus infection, and the CT findings are not suggestive of the classic "halo sign" described in patients with angioinvasive aspergillosis.

Although many bacterial infections can cause rhabdomyolysis, two pathogens warrant special consideration: streptococcus and legionella. Infection with either of these bacteria can cause rhabdomyolysis and lung consolidation and can result in a disease similar to that observed in this patient, in terms of severity and acute onset.[9-11] It is worth reevaluating this patient's presenting symptoms to determine whether they are compatible with pneumonia. Case series of legionella pneumonia and streptococcal pneumonia indicate that some patients present without cough, dyspnea, and chest pain.[11,12] Myalgias, confusion, and nonfocal neurologic symptoms — findings that were seen in this case — are common in patients with legionella infection (also known as legionnaires' disease) and occur less often in those with streptococcal infection. Together, these features suggest that we can link the cause of the two previously identified prime movers — lung consolidation and rhabdomyolysis — with a bacterial infection.

DISTINGUISHING LEGIONELLA FROM STREPTOCOCCAL INFECTION

Either legionella or streptococcal infection could be the cause of this patient's illness. The findings on presentation and results of laboratory tests alone cannot reliably distinguish one from the other. In more than half of pneumonia cases, no causative pathogen is identified. In this case, it was prudent to treat both causes empirically. As I try to distinguish one cause from the other, I will review the case details that may inform the final diagnosis.

Certain features of this patient's presentation favor the diagnosis of legionella infection. He lives in a converted factory. Although the data are far from conclusive, the transmission of legionella appears to be related to building environment factors (particularly plumbing), and it is reported more often in large buildings than in single-family homes.[13] In addition, rhabdomyolysis is more commonly associated with legionella infection than with streptococcal infection. Nonspecific laboratory findings in this patient also fit with a diagnosis of legionella. These include hyponatremia, leukocytosis with lymphopenia, an erythrocyte sedimentation rate greater than 90 mm per hour, a blood level of C-reactive protein greater than 180 mg per liter, microscopic hematuria, elevated levels of aspartate aminotransferase and alanine aminotransferase, a ferritin level of more than twice the upper limit of the normal range, and an elevated level of lactate dehydrogenase.[14-16] The absence of gastrointestinal symptoms is notable, since such symptoms are a common feature of legionella infection.

After developing the differential diagnosis, I would frame the problem representation in this case as a 47-year-old man residing in a converted factory who presents with acute community-acquired pneumonia complicated by rhabdomyolysis, oliguric kidney failure, liver injury, and encephalopathy. I favor an infectious cause, given the acute onset and severity of the presentation. Specifically, I think the most likely diagnosis is legionella infection, and I would obtain a specimen of urine for legionella antigen testing.

DR. SACHIN J. SHAH'S DIAGNOSIS

Legionella infection.

LABORATORY TESTING

Dr. Sanjat Kanjilal: The diagnostic test in this case was a legionella urinary antigen test, which was positive and confirmed the diagnosis of legionella infection. *Legionella pneumophila* is an aerobic, fastidious gram-negative bacillus that is ubiquitous in the environment, with a preference for warm, freshwater habitats. The organism grows at temperatures ranging from 20 to 42°C and can be found in high concentrations in contaminated water towers and warm piping, often in complex microbial communities embedded within biofilms. Human disease usually occurs after disturbance of a biofilm, subsequent aerosolization, and then inhalation of many organisms by a susceptible host. Although we could not prove it, we suspected that this patient was probably exposed from the ventilation system in his home, which was an old factory that had been converted into apartments. Given the severity of his symptoms on presentation, we presumed that he had in-

haled a large burden of organism, although he had few of the risk factors for poor outcomes, which include older age, male sex, heavy smoking, coexisting chronic cardiovascular conditions, end-stage kidney disease, and immunocompromise related to glucocorticoid exposure or solid-organ transplantation.

There is great diversity within the legionella genus in terms of both species and species-specific serotypes, but up to 98% of legionella infections are linked to *L. pneumophila* serogroup 1. The Pontiac monoclonal subgroup of serogroup 1 is isolated in 80 to 90% of clinical isolates, and it is the target of the urinary antigen test.

The identification of legionella as the causative agent in disease can be challenging (Fig. 2). The organism is very difficult to visualize on Gram's staining because of the unique composition of its lipopolysaccharide, which does not bind with the safranin red counterstain that is used to identify gram-negative organisms. Legionella has a coccobacillary appearance in sputum and tissue, which differs from the long, thin rod appearance it forms when growing in culture. The changes in shape may reflect the ability of the organism, when in its natural habitat, to switch between a replicative state (which exists inside a host cell) and a transmissive state (in which it decreases in size and becomes motile to facilitate searching for a new host cell). The sensitivity of culture is directly related to the severity of infection, which is associated with the organism burden present in the host at the time of sampling.

In this patient, despite the presence of clear lobar consolidation, legionella was not isolated in culture from a sputum specimen that was obtained 48 hours after admission. This may be explained by the combination of poor sample quality owing to the patient's altered mental status, previous exposure to antibiotic agents, and the challenges of growing legionella in vitro. Culture of the organism requires agar supplemented with iron, cysteine, and α-ketoglutarate, as well as a tightly controlled pH and activated charcoal to remove toxic oxygen radicals. In addition, culture media is often supplemented with antibiotics because of the potential for overgrowth by typical respiratory flora. In this case, Gram's staining of the sputum specimen showed rare polymorphonucleocytes and no organisms. This appearance is typical of pneumonia due to legionella, which is often characterized by a lack of neutrophils in sputum specimens. This factor may lead microbiology laboratories that use neutrophil count as part of the scoring criteria for sputum quality to inadvertently reject viable specimens. In cases in which legionella pneumonia is on the differential diagnosis, the laboratory should be notified to culture any sputum specimens regardless of the scoring criteria.

Urinary antigen testing has become the standard method for the diagnosis of infection with *L. pneumophila* serogroup 1. Several Food and Drug Administration–approved commercial assays are available, with the most common being a lateral flow assay. All these assays are designed to detect the lipopolysaccharide from the Pontiac monoclonal subgroup of *L. pneumophila* serogroup 1, and the clinical sensitivity is estimated to be 90% for severe infections from this subgroup. However, the sensitivity decreases to 50% among patients with mild cases that do not result in hospitalization and ranges from 5 to 40% among patients with infection due to other serogroups or species. Antigenuria may be detectable for weeks to months after infection and does not indicate ongoing infection. The NAAT has higher sensitivity than culture and urinary antigen testing and allows for the detection of all *L. pneumophila* strains, as well as other legionella species. However, the NAAT can be performed only at reference laboratories and, like all molecular tests, cannot differentiate viable from nonviable organisms. Table 2 describes the different diagnostic tests for legionella infection and their characteristics.

LABORATORY DIAGNOSIS

Infection with *Legionella pneumophila* serogroup 1.

DISCUSSION OF MANAGEMENT

Dr. Kanjilal: The patient initially received treatment with ceftriaxone and azithromycin, in accordance with guidelines from the American Thoracic Society for the treatment of severe community-acquired pneumonia that results in hospitalization.[17] The antimicrobial regimen was narrowed to azithromycin after the diagnosis of legionella infection was made, and his fevers, mental status, and supplemental oxygen requirement gradually improved over the next 4 days. Treatment was briefly transitioned to doxycycline on hospital day 5 owing to concern for QT prolongation; however, after his hypoxemia notably worsened

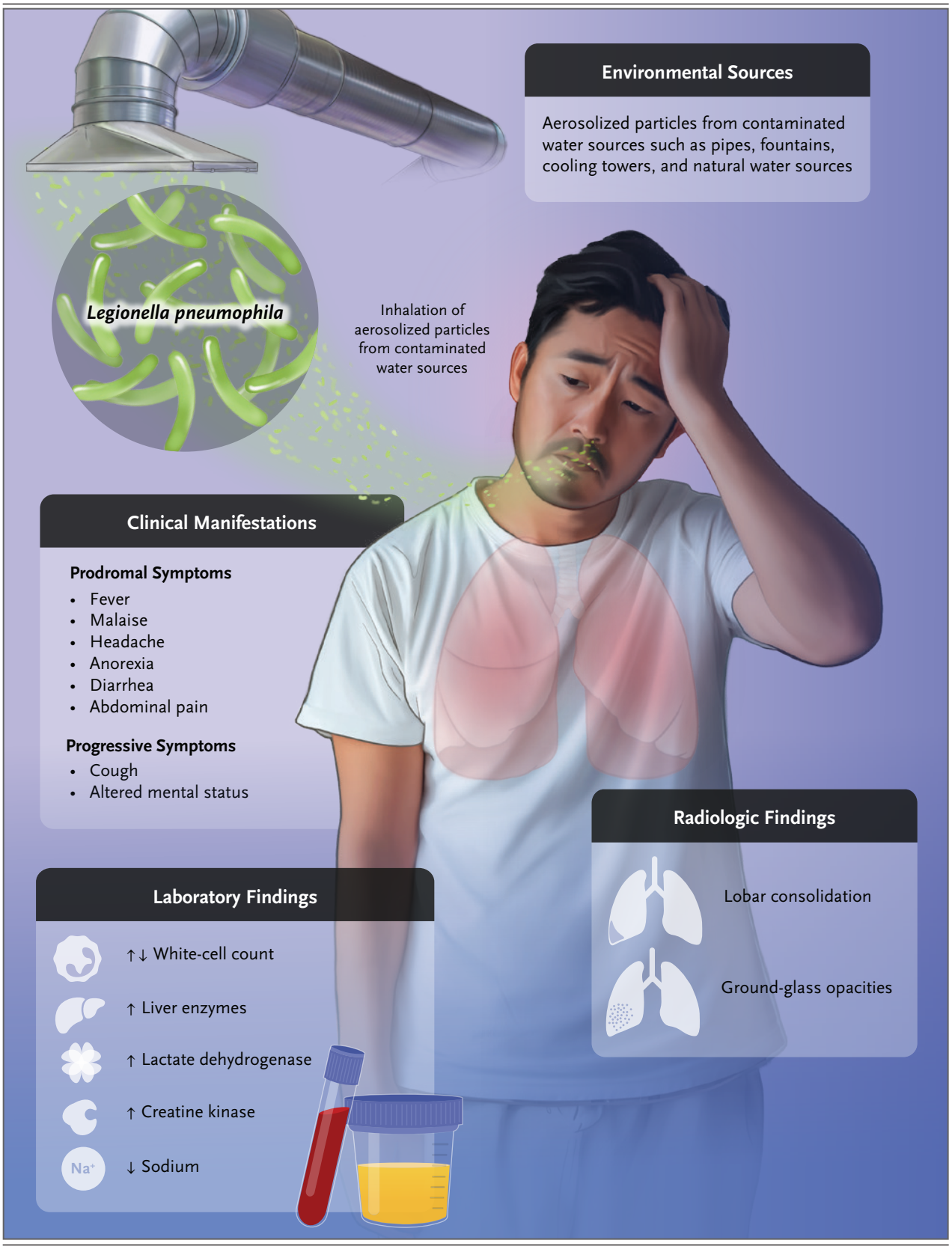

Figure 2 (facing page). Environmental Sources, Clinical Manifestations, Laboratory Findings, and Radiologic Findings of Legionella Pneumonia.

Transmission typically occurs through aerosolization from an environmental source. Inhalation and inoculation result in prodromal symptoms, including fever, malaise, and headache. Over the course of several days, a cough develops that may or may not be productive of purulent sputum. Altered mental status is frequently described with severe cases. Nonpulmonary symptoms, such as headache and gastrointestinal symptoms, may be severe and lead to misdiagnosis. Laboratory findings are consistent with severe community-acquired pneumonia and may show leukocytosis or leukopenia, elevated levels of liver enzymes, lactate dehydrogenase, and creatine kinase, and hyponatremia; however, these findings lack specificity. Radiologic findings nearly always include a consolidating pneumonia at the time of presentation. Extrapulmonary infection is rare and occurs almost exclusively in immunocompromised patients.

and fevers returned, the decision was made to discontinue doxycycline and restart macrolide therapy. Repeat chest imaging showed worsening ground-glass opacities, but sputum cultures remained negative. The patient's treatment regimen was transitioned to levofloxacin monotherapy on hospital day 9. He had a rapid resolution of his supplemental oxygen requirement and fever, as well as a return to his baseline mental status. In total, he completed 10 days of pathogen-directed therapy.

Treatment decisions for legionella pneumonia are made on the basis of retrospective studies.[18,19] The organism replicates inside alveolar macrophages; therefore, the antibiotic classes used for treatment include tetracyclines, macrolides, and fluoroquinolones because they penetrate the human cell membrane and remain bioactive. Beta-lactams and aminoglycosides are not effective in this context. Several meta-analyses have shown fluoroquinolones to be either equivalent or superior to macrolides; results varied according to whether the comparator was azithromycin, which has the highest activity against legionella, or clarithromycin or erythromycin.[20,21] Although data are limited, tetracyclines are generally avoided, unless the patient has unacceptable side effects with macrolides or fluoroquinolones. The prevention of legionellosis typically involves identification and decontamination of the environmental source of infection. In this case, the source was probably the ventilation system of the converted factory where the patient was living.

Given the patient's metabolic derangement and oliguric kidney failure, the nephrology service was consulted, and an emergency hemodialysis catheter was placed immediately after admission. A transthoracic echocardiogram (TTE) obtained on hospital day 2 showed a diffusely hypokinetic left ventricle with no regional wall-motion abnormalities and with an ejection fraction of 37%. Treatment was started with isosorbide dinitrate, hydralazine, and metoprolol for the management of heart failure. His kidney function recovered over the next 2 weeks, and the temporary dialysis catheter was removed on hospital day 10. No kidney biopsy was performed, and the acute kidney injury was attributed to rhabdomyolysis and severe infection. A repeat TTE obtained 9 days after the first showed full recovery of the left ventricular ejection fraction; therefore, the previous cardiomyopathy was determined to be stress-related.

The patient was discharged on hospital day 16, at which point he needed oxygen support only when he was ambulating. At a follow-up visit in his primary care clinic 3 weeks later, the blood levels of electrolytes, urea nitrogen, and creatinine had returned to baseline, and he no longer had dyspnea on exertion or orthopnea. Two months

Table 2. Characteristics of Common Diagnostic Tests for Legionella Pneumonia.*

Test	Specimen Type	Sensitivity	Specificity
		percent	
Culture	Sputum, bronchoalveolar lavage, tissue, and blood	20–95	100
Antigen	Urine	60–95	>99
PCR	Sputum and bronchoalveolar lavage	70–95	95–99
Antibody	Serum	20–70	95–99
Immunofluorescence	Sputum, bronchoalveolar lavage, tissue, and blood	20–50	99

* PCR denotes polymerase chain reaction.

after discharge, he was weaned off his cardiovascular medications. Five months after discharge, the only symptom reported by the patient was a mental "fog."

Dr. Kathy M. Tran (Medicine): Could the patient's family history of myopathy have contributed to this presentation?

Dr. Shah: Researchers have sought to identify a genetic predisposition to rhabdomyolysis. Genetic variants that affect glycolysis, lipid metabolism, Krebs cycle proteins, the purine nucleotide cycle, and the mitochondrial respiratory chain and can result in muscular dystrophies appear to increase the susceptibility to rhabdomyolysis.[22-24] A cross-reference of the genes that have been identified as causes of nemaline myopathy and those associated with rhabdomyolysis does show at least one variant found in both (*RYR1*).[25] A muscle biopsy and genetic testing (if not already completed) would need to be performed to further investigate whether the family history of nemaline myopathy could have contributed to his presentation.

FINAL DIAGNOSIS

Legionella infection complicated by rhabdomyolysis.

This case was presented at Medicine Case Conference, Interview Series.

Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

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