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Sarcoidosis and burn pit exposure in military deployers to Iraq, Afghanistan, and Southwest Asia

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Abstract. *Background and aim:* Inhalational exposures have been hypothesized to play a role in the pathogenesis of sarcoidosis. Herein, we describe a cohort of US Military personnel diagnosed with sarcoidosis during or after deployment to Southwest Asia and Afghanistan, who experienced complex inhalational exposures to burn-pits and desert dust. *Methods:* Consecutive military personnel at four sub-specialty clinics across the United States were screened for deployment to Southwest Asia and Afghanistan and diagnosis of sarcoidosis based on 1999 ATS/ERS/WASOG Statement on Sarcoidosis. Detailed demographic, deployment and exposure data was collected. The data combined was analyzed after de-identification and local IRB approval. *Results:* Twenty-one patients met our case definition. Seventeen patients were male and 62% had extrapulmonary involvement, including 38% with musculoskeletal involvement. *Conclusions:* Our study suggests that the sarcoidosis in military personnel to Southwest Asia can be diagnosed many years after deployment. To our knowledge, this is the first case series to describe a group of military personnel diagnosed with sarcoidosis and exposures specific to military deployment to Southwest Asia.

Key words: sarcoidosis, burn pits, veterans, military, desert dust

Introduction

For over a century, researchers have used a variety of approaches to try to identify the etiology of sarcoidosis. The current prevailing hypothesis is that sarcoidosis is the result of exposure to certain antigens, resulting in alterations in host immune response in a genetically susceptible host (1). Despite numerous studies, no single occupational or environmental exposure has been reproducibly linked to the development of sarcoidosis (1–4).

While exposure-related sarcoidosis is not well-defined, an increased incidence of sarcoidosis has been reported in several cohorts with notable inhalational exposures. For example, the New York City Fire Department rescue workers present during the World Trade Center (WTC) disaster had a 0.086% incidence of sarcoidosis in the first year after exposure, compared to a 0.015% incidence in the years prior to the disaster (5). There have been similar concerns about poor air quality from burn pit emissions and desert dust in the military population that has deployed to Southwest Asian countries including Iraq, Afghanistan, Kuwait, and Saudi Arabia (6–11). New-onset respiratory conditions in the deployed military population have been reported during the First Gulf

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War in which approximately 697,000 military personnel were deployed to the Persian Gulf region from 1990 to 1991 (12), and after September 11, 2001 in ongoing military operations deploying over 3 million military personnel to Afghanistan and Iraq (6). Similarities in the exposures encountered during these deployments raise concern for a subset of unrecognized respiratory illnesses. Inhalational exposures in this population include sandstorms, high ambient particulate matter (PM) concentrations, burn pits and trash-burning emissions, and exhaust from gasoline, jet fuel, rocket propellants, and diesel (12–14).

A case series from 2011 that reported findings of constrictive bronchiolitis in post-9/11 deployed military personnel, also reported histopathologic findings which could be consistent with sarcoidosis in two deployers (15). A more recent study that examined lung biopsies from 391 military personnel, 137 of whom had deployed to Southwest Asia prior to undergoing lung biopsy, found that non-necrotizing granulomatous inflammation was more common in Southwest Asia deployers than in the non-deployed group with an odds ratio of 2.4 (16).

A retrospective case–control study published in December 2022 examined risk factors associated with development of sarcoidosis based on demographics and self-reported cumulative exposures during deployment and found that the highest risk of developing sarcoidosis was in veterans who participated in convoy activities with a marginally statistically significant odds ratio of 1.16 (17).

Studying this population for respiratory conditions including sarcoidosis is important because a large population may be at risk for developing a chronic medical condition. In addition, studying sarcoidosis in military deployers may provide new insight into the relationship between inhalational exposures and the development of sarcoidosis.

We therefore sought to describe military personnel who presented with new-onset respiratory symptoms during or following deployment to Southwest Asia and Afghanistan and were diagnosed with sarcoidosis at four subspecialty clinics across the United States between 2012 and 2019.

Methods

Our retrospective, case-series includes patients with a diagnosis of sarcoidosis made during or after military deployment to Southwest Asia or Afghanistan who were evaluated between July 1, 2012, to January 31, 2019, at National Jewish Health (Denver, Colorado), Oklahoma City Veterans Administration Health Care System (Oklahoma City, Oklahoma), University of Florida (Gainesville, FL), and Vanderbilt University Medical Center (Nashville, Tennessee). The study was conducted in accordance with the Declaration of Helsinki and the protocol was approved by each local Institutional Review Board with waiver of consent.

Eligible subjects were consecutive military personnel with a diagnosis of sarcoidosis made using the 1999 American Thoracic Society/World Association of Sarcoidosis and Other Granulomatous Lung Disorders (WASOG) Statement on Sarcoidosis either during or after deployment to Southwest Asia or Afghanistan as a part of Operation Desert Shield, Operation Desert Storm, Operation Enduring Freedom, Operation Iraqi Freedom, Operation New Dawn, and Operation Freedom's Sentinel. We excluded deployers who had a diagnosis of sarcoidosis, any chronic respiratory illness, or any respiratory symptoms prior to deployment.

Demographic and clinical characteristics abstracted from charts included age, sex, smoking history, age at diagnosis of sarcoidosis, biopsy site, organ involvement, symptoms, treatment, deployment location, deployment dates, deployment duration, and exposure history. Organ involvement was determined using the WASOG Organ Assessment Instrument (18). Pulmonary function tests (PFT) were performed at each individual clinic and followed ATS standards for performing these tests. PFT reference values were race-specific amongst all institutions, and were either based on the NHANES III or Crapo 1981 reference models (19,20). PFT and imaging findings from the first clinic visit were recorded. Improvement was defined as improvement in symptoms, PFT, or radiographic findings. All data was de-identified prior to analysis. Descriptive statistics were performed using SAS/STAT© software version 9.3.

The WASOG organ assessment instrument (18) was used to classify various organ involvement of sarcoidosis. The organ systems focused on were lung, skin, eye, calcium-vitamin D, bone/joint, muscle, extrathoracic lymph nodes, nervous system, and cardiac. Organ system involvement was classified per the assessment instrument into "highly probable", "at least probable," and "possible" categories. These criteria used are summarized in Table 1. Table 2 lists organ involvement of our patient series with probabilities as outlined by these criteria.

Results

Demographics of military deployers with sarcoidosis, disease characteristics, and management

A total of 21 patients met the case-definition. Eleven patients were enrolled from Vanderbilt University Medical Center, five patients from National Jewish Health, four patients from Oklahoma City Veteran's Administration Health Care Center, and one patient from the University of Florida. Of this population, the majority were men and average age at time of sarcoidosis diagnosis was 41 years (IQR 34-49.5) (Table 3). Ten patients (47.6%) were

Table 1. Probability of organ involvement in sarcoidosis as per the WASOG sarcoidosis organ assessment instrument ((18)).

System	Highly Probable	At Least Probable	Possible
Lung	CXR: bilateral hilar adenopathy. CT: perilymphatic nodules, symmetrical hilar/mediastinal adenopathy PET: mediastinal/hilar enhancement.	CXR: diffuse infiltrates, upper lobe fibrosis. CT: peribronchial thickening. PET: diffuse parenchymal lung enhancement. BAL: lymphocytic alveolitis, elevated CD4/CD8 ratio. TBNA: lymphoid aggregates/giant cells.	CXR: localized infiltrate. PFT: obstruction.
Skin	Lupus pernio.	Subcutaneous nodules or plaques, inflammatory papules within a scar/tattoo, violaceous or erythematous either annular lesions or maculopapular lesions around the eyes, nose, or mouth.	Ulcerative, erythrodermic, alopecic, ichthyosiform lesions.
Eye	Uveitis, optic neuritis, mutton fat keratic precipitates, iris nodules, pars planitis.	Lacrimal gland swelling, trabecular meshwork nodules, retinitis, scleritis, chorioretinal peripheral lesions, adnexal nodularity, candle wax drippings.	Cataracts, glaucoma, red eye.
Calcium-Vitamin D	Hypercalcemia or hypercalciuria with normal serum PTH, normal/increased 1,25-OH dihydroxy vitamin D, low 25-OH vitamin D.	Nephrolithiasis with normal serum PTH, normal/increased 1,25-OH dihydroxy vitamin D, low 25-OH vitamin D. Hypercalciuria or nephrolithiasis with calcium stones without serum PTH, 25/1,25 vitamin D levels.	Nephrolithiasis without stone analysis.
Bone-Joint	Radiographic features such as trabecular pattern, osteolysis, cysts/punched out lesions.	Dactylitis, nodular tenosynovitis, positive PET/MRI bone imaging.	Arthralgias.
Extrathoracic Lymph Node		Multiple enlarged palpable cervical/epitrochelear lymph nodes without B-symptoms. Enlarged lymph nodes identified by imaging in at least two peripheral/visceral lymph node stations without B-symptoms.	
Nervous System	Clinical syndrome consistent with granulomatous inflammation of the meninges, brain, CSF, cranial nerves, pituitary gland, spinal cord, cerebral vasculature, or nerve roots with abnormal MRI characteristic of neurosarcoidosis (abnormal enhancement following administration of gadolium) or inflammatory CSF profile.	Isolated facial palsy or clinical syndrome consistent with granulomatous inflammation of the meninges, brain, CSF, cranial nerves, pituitary gland, spinal cord, cerebral vasculature, or nerve roots without characteristic MRI/CSF findings.	Seizures or cognitive decline with negative MRI.
Cardiac		Treatment responsive cardiomyopathy or AV nodal block, reduced LVEF without other clinical risk factors, spontaneous/inducible sustained VT without other risk factors, Mobitz type II or complete heart block, patchy uptake or T2 prolongation on dedicated cardiac PET, delayed enhancement on cardiac MRI, positive gallium uptake, defect on perfusion scintigraphy/SPECT.	Reduced LVEF in the presence of other risk factors, atrial dysrhythmias.

Table 2. Characteristics of all individual patients with pulmonary sarcoidosis.

Patient	Age at Diagnosis	Sex	Race	Smoking History	Biopsy Method	Biopsy Site	Organ Involvement	Lung Imaging Findings	Symptoms and Manifestations	Treatment	Outcome
1	36	M	White	Former	Mediastinoscopy, Thoracoscopy	LN, Lung	Lung (HP)	Mediastinal/ Hilar LN	SOB	None	Improved
2	69	M	Black	Former	TBBX	Lung	Lung (HP)	Mediastinal LN, Nodules	SOB	None	Improved
3	41	M	White	Never	TBBX	Lung	Lung (HP), Bone-Joint (P), Muscle (P)	Nodules	Arthralgias	None	Improved
4	34	M	White	Never	Mediastinoscopy	LN	Lung (HP), Bone-Joint (P), Muscle (P)	Mediastinal/ Hilar LN	Fever, Arthralgias	Systemic Steroids (PO)	Improved
5	41	M	Black	Never	TBBX	Lung	Lung (HP)	Mediastinal LN, Fibronodular Infiltrate	SOB	Inhaled Corticosteroids	Improved
6	32	F	Black	Never	Mediastinoscopy	LN	Lung (HP)	Mediastinal LN	SOB	Systemic Steroids (PO)	Improved
7	49	M	White	Never	EBUS	LN	Lung (HP)	Mediastinal/ Hilar LN, Nodules	None	None	Unchanged
8	45	M	White	Former	Mediastinoscopy	LN	Lung (HP)	Mediastinal/ Hilar LN	SOB	Systemic Steroids (PO)	Improved
9	40	M	White	Never	Mediastinoscopy	LN	Lung (HP), Bone-Joint (P), Muscle (P)	Mediastinal/ Hilar LN	Myalgias, SOB	Systemic Steroids (PO)	Unchanged
10	34	M	White	Former	Mediastinoscopy	LN	Lung (HP), Extrathoracic Lymph Nodes (ALP), Calcium-VitD (HP)	Diffuse LN	Abdominal Pain, Hypercalcemia	Systemic Steroids (PO)	Improved
11	27	M	White	Current	None	None	Lung (HP), Bone-Joint (P), Muscle (P)	Mediastinal/ Hilar LN	Arthralgias	None	Improved

12	41	F	Black	Former	TBBX	Lung	Lung (HP), Skin (P), CNS (HP)	Mediastinal LN	Cough, CP	Systemic Steroids (PO), MTX, Adalimumab	Unchanged
13	33	M	White	Never	VATS	Lung	Lung (HP), Cardiac (P)	Mediastinal/ Hilar LN	Fatigue, NICM	Systemic Steroids (PO)	Worsened
14	50	M	White	Never	VATS	Lung	Lung (HP)	Hilar LN, Nodules	SOB	Systemic Steroids (PO), MTX, MMF, Rituximab	Unchanged
15	57	M	White	Never	VATS	Lung	Lung (HP)	Hilar LN, Nodules	Cough, SOB	Systemic Steroids (PO)	Improved
16	57	M	White	Never	TBBX	Lung	Lung (HP), Cardiac (P)	Mediastinal/ Hilar LN	Cough	Systemic Steroids (PO), MTX, Hydroxychloroquine	Improved
17	40	M	White	Former	Bone Marrow Biopsy, TBBX	Bone Marrow, Lung	Lung (HP), Bone-Joint (P), Muscle (P)	Nodules	Arthralgias, DOE	Systemic Steroids, MTX	Worsened
18	52	M	Black	Former	EBUS	LN	Lung (HP), Bone-Joint (P), Muscle (P), CNS (ALP)	Mediastinal/ Hilar LN, Nodules	Weakness	Systemic Steroids (IV)	Improved
19	31	F	White	Current	EBUS	LN	Lung (HP), Calcium-VitD (ALP)	Mediastinal LN	Abdominal Pain (nephrolithiasis)	None	Unchanged
20	44	M	White	Former	EBUS	LN	Lung (HP), Bone-Joint (P), Muscle (P)	Mediastinal LN	Cough, Arthralgias	Systemic Steroids (PO/IV), MTX	Unchanged
21	46	F	Black	Never	TBBX	Lung	Cardiac (P), Bone-Joint (P), Muscle (P), CNS (P), Eye (HP)	None	Uveitis, Arthralgias, Palpitations, Syncope	Systemic Steroids (PO)	To be Determined

For organ involvement based on WASOG definitions (table 4), HP: highly probable; ALP: at least probable, and P: possible. CNS: central nervous system; CP: chest pain; DOE: dyspnea on exertion; EBUS: endobronchial ultrasound; F: female; IV: intravenous; LN: lymph node; M: male; MTX: methotrexate; MSK: musculoskeletal; NICM: non-ischemic cardiomyopathy; PO: oral; SOB: shortness of breath; TBBX: transbronchial biopsy; VATS: video-assisted thoracoscopic surgery.

Table 3. Demographic and clinical characteristics of patients with sarcoidosis.

Characteristic	Total Population (n = 21)
Sex (% male)	17 (81.0)
Number of Pre-9/11 Deployers (%)	7 (33.3)
Number of Post-9/11 Deployers (%)	14 (66.7)
Median Age at Sarcoid Diagnosis (IQR)	41 (34-49.5)
Diagnosis by Biopsy (%)	20 (95.2)
Current/Prior Smoker (%)	10 (47.6)
Extrapulmonary Sarcoidosis (%)	13 (61.9)
Treatment with Systemic Steroids Only (%)	9 (42.9)
Number of Deployers with FVC < 80% (%)	4 (19.0)
Number of Deployers with FEV1/FVC < 70% (%)	2 (9.5)
Number of Deployers with DLCO < 80% (%)	10 (47.6)

current or former smokers. All but one patient (95%) had undergone a biopsy procedure for diagnosis. If the diagnosis was made by biopsy, it was by either mediastinoscopy, thoracoscopy, or transbronchial biopsy (with or without endobronchial ultrasound guided transbronchial needle aspiration) (Table 2 and Table 4).

Lungs were involved in all but one patient. Four patients (19%) had PFT demonstrating FVC< 80%, two patients (9.5%) demonstrated FEV1/FVC < 70%, and 10 patients (47.6%) demonstrated DLCO < 80% (Tables 3-4). Chest imaging abnormalities were seen in 20 out of 21 patients and primarily consisted of hilar and mediastinal lymphadenopathy and lung nodules. Eight patients had Scadding Stage 1 disease (38%), 7 had Scadding Stage 2 disease (33%), 2 had Scadding Stage 3 disease (10%) and 2 had Scadding Stage 4 disease (10%). More than half of the patients experienced extrapulmonary symptoms (62%). Musculoskeletal involvement comprising of both "Bone-Joint" and "Muscle" categories from the WASOG Organ Assessment Instrument was the second most common system involvement with 8 out of 21 patients affected (38%).

A total of 15 patients (71%) received treatment. Methotrexate was most frequently used steroid-sparing agent. Twelve patients saw improvement in symptoms during the course of the study. Of these, four had spontaneous improvement. Eight of fifteen patients (53%) exhibited improved symptoms on medical therapy. Six of fifteen patients (40%) treated were unchanged or worsened on therapy. In one patient, there was not enough follow up time to determine outcome.

Deployment and exposure history

The majority (67%) of patients were deployed after September 2001, with the remainder (33%) deployed in either Operation Desert Shield or Operation Desert Storm. Deployment locations included Iraq, Kuwait, Saudi Arabia, Qatar, Oman and Afghanistan. The length of deployment was between 3 and 60 months (Table 5). The median time from last day of deployment to symptom onset was 36 months (IQR 6.0-85.8). Eight out of 21 (38%) had symptom onset within one year of deployment and four (19%) had symptom onset within five years of deployment. The median time from the last day of deployment to sarcoidosis diagnosis was 85 months (IQR 36-156). In seven patients (33%), sarcoidosis was diagnosed within 5 years. In six patients (29%), the diagnosis was made 10 years or later after deployment. The primary exposures reported included burn pits, desert dust, sandstorms, and improvised and other explosive devices.

Discussion

We describe clinical findings and military exposure characteristics in 21 military personnel evaluated at four subspecialty pulmonary clinics in the United States who were diagnosed with sarcoidosis during or after deployment to Afghanistan, Iraq, and other parts of Southwest Asia. To our knowledge, this is the first case series to describe sarcoidosis in a group of military deployers with exposures specific to the military operations in Southwest Asia and Afghanistan.

The landmark A Case Control Etiologic Study of Sarcoidosis (ACCESS) study included extensive occupational and environmental exposure history including an occupational category termed "Military," subdivided into the branches of the military (21). In this cohort of 706- matched case-control pairs, 2% held jobs in the military for at least 6 consecutive months. The investigators' *a priori* hypothesis included a positive predicted association between

Table 4. Pulmonary function testing at the time of sarcoidosis diagnosis.

Patient	FVC		FEV1		FEV1/FVC Ratio	TLC		DLCO	
	L	%	L	%		L	%	mL/mmHg/min	%
1	5.06	91	4.37	95	86	6.82	93	26.72	76
2	4.25	108	3.13	107	74	6.80	101	25.96	71
3	5.04	105	3.92	101	78	6.52	99	34.32	110
4	5.21	95	4.09	92	79	6.43	90	25.56	76
5	2.45	57	2.23	62	91	4.02	69	18.71	75
6	3.22	76	2.58	73	80	4.77	82	21.08	80
7	3.72	75	2.76	71	74	6.61	92	24.75	85
8	4.57	88	3.28	80	79	7.21	104	37.97	119
9	4.53	91	3.63	92	80	6.37	97	27.53	86
10	5.64	94	4.65	95	82	6.28	81	27.64	77
11	5.34	97	3.91	85	73	6.63	95	32.40	98
12	2.86	86	2.08	77	73	5.22	96	5.70	103
13	5.35	83	4.26	82	80	8.14	96	32.59	70
14	3.85	80	2.21	58	57	6.10	22	22.49	79
15	2.35	52	1.93	54	82	4.64	73	18.47	68
16	5.30	104	4.51	116	85	-	-	29.85	81
17	5.92	89	4.38	90	79	8.31	88	34.73	88
18	3.11	85	2.33	79	75	4.84	81	15.20	66
19	3.89	101	2.91	89	78	5.30	99	19.50	80
20	3.79	86	2.62	75	69	6.04	106	20.90	83
21	3.27	99	2.43	90	74	5.67	104	20.10	76

Abbreviations: DLCO: diffusion capacity of the lung for carbon monoxide; FEV1: forced expiratory volume in one second; FVC: forced vital capacity; TLC: total lung capacity.

Military occupations and sarcoidosis compared to controls, but no association was detected.

Compared to the ACCESS cohort, our patients had significantly more bone/joint and muscle involvement (0.1% versus 38%). One explanation for some of the difference may be that the ACCESS Organ Involvement Instrument used to define organ involvement used different criteria than the WASOG Organ Assessment Tool that our study utilized to define organ assessment. Nonetheless, it likely does not explain the entire difference and we hypothesize that since the military deployers to Southwest Asia cohort are by far men with a unique set of exposures, the high frequency of musculoskeletal involvement may could represent a unique phenotype similar to the WTC disaster site exposed Fire Department of New York cohort.

Over the past 15 years, there has been an increasing recognition of new onset respiratory symptoms following deployment to the Southwest Asia region, referred to as deployment-related lung disease. Its' presentation is heterogenous and includes rhinosinusitis, asthma, and constrictive bronchiolitis. A prospective large study published in 2009 using data on 46,077 Millennium Cohort Study participants who completed baseline (July 2001–June 2003) and follow-up questionnaires showed that deployers had a higher rate of newly reported respiratory symptoms than non-deployers (14% vs. 10%) (9). Among deployers, elevated odds of symptoms were associated with land-based deployment as compared with sea-based deployment, suggesting that exposures related to ground combat may be important. Respiratory conditions were also found to be common (18%) in a review of the clinical findings in the first 1000 veterans seen in the Ministry of Defense's Gulf War medical assessment program between 1993 and 1997 (22). A cross sectional study compared 1456

Table 5. Deployment information prior to sarcoidosis diagnosis.

Patient	Deployment Locations	Cumulative Southwest Asia Deployment Duration (months)	Time from Deployment to Symptom Onset (months)	Time from Deployment to Sarcoidosis Diagnosis (months)
1	Iraq	8	0	42
2	Iraq	6	228	228
3	Iraq, Kuwait	24	3	36
4	Iraq	3	7	7
5	Iraq	15	6	24
6	Iraq	12	0	96
7	Iraq	15	144	144
8	Iraq, Kuwait	3	228	240
9	Iraq	-	36	36
10	Afghanistan, Iraq	60	-	-
11	Afghanistan, Iraq	12	36	-
12	Iraq	15	74	76
13	Iraq, Kuwait	9	79	85
14	Iraq	30	88	109
15	Iraq	12	6	96
16	Saudi Arabia	6	0	180
17	Oman, Iraq, Qatar	21	48	72
18	Iraq, Kuwait	36	264	288
19	Afghanistan	12	48	48
20	Oman	4	12	156
21	Iraq	24	24	24

Australian Gulf War veterans with 1588 randomly sampled military veterans and showed that the Gulf War veterans had a higher-than-expected prevalence of respiratory symptoms and respiratory conditions. Veterans who reported exposure to oil fire smoke had slightly poorer forced vital capacity, and veterans who were in the Gulf at or after the start of the oil fires had more respiratory conditions suggesting asthma than those who completed their deployment before this time. The findings from our case series may represent a similar effect of deployment-related exposures in military personnel deployed to the Southwest Asia region but resulting in a unique deployment-related lung disease, sarcoidosis, which has not been described in prior studies.

Although not specifically explored in this study, given that an association between sarcoidosis and military deployment for US veterans has been established, the burden of sarcoidosis and other respiratory diseases may be increased in the native Southeastern Asia population due to extended exposures; however, specific data regarding rates in this population is beyond the scope of this investigation. Notably, access to burn pits and other sources of known exposures are severely restricted to military personnel, thus may not contribute as much of an environmental risk factor for civilians.

There are several limitations in our study. One is the lack of objective pre-deployment health data to confirm that sarcoidosis was not present before deployment. To address this limitation, we ensured deployers who were enrolled had no respiratory symptoms prior to deployment and actively excluded those cases with respiratory symptoms, a diagnosis of sarcoidosis, or any other chronic respiratory condition prior to deployment. Another limitation is the lack of comparison group. Furthermore, given the retrospective nature of this study, the generalizability of findings is limited by the possible selection of cases with more advanced phenotypes of lung disease and

extrapulmonary sarcoidosis involvement, compared to the distribution of cases that would otherwise be identified with systematic sampling of this patient population. To address this, our team attempted to gain access to the VA Airborne Hazards and Open Burn Pit Registry to more thoroughly identify veterans that have been granted benefits from burn pit exposures. However, due to VA access restrictions, this was not feasible at the time of this study, yet the registry remains an available resource for future investigators interested in further exploring health ramifications from these exposures in our veteran community. Despite this limitation, we completed extensive informal searches of electronic health records to maximize the number of identified patients meeting inclusion criteria. Our aim in this paper was to draw attention to this cohort of patients and we argue that military personnel are an understudied cohort. Finally, many assessments of sarcoidosis organ involvement, such as that with bone and joint, have significant overlap with many existing service-related comorbidities of current U.S. service members. Many service members have sequelae of physical trauma from their deployment. Our small sample size and lack of comparison group makes it difficult to distinguish musculoskeletal symptoms related to deployment from sarcoidosis related bone and joint involvement. Additionally, highly probable requires either PET or MRI to evaluate for musculoskeletal involvement of sarcoidosis. These can be costly and difficult to obtain tests not easily available to patients at all patient centers. Access to the VA Airborne Hazards and Open Burn Pit Registry and a larger population of patients would help create a study that could better differentiate between symptoms associated with sarcoidosis or those associated with various deployments.

The true incidence and prevalence of sarcoidosis in the military and in military deployers is unknown. In one recent study, the prevalence of sarcoidosis from the U.S. military health system data repository between 2004 to 2013 was reported to be 78 per 100,000 but over half of the cohort were dependents of active or retired personnel and only 17% of the cohort was on active duty (23). Studying deployers who are later diagnosed with sarcoidosis is also limited by the inability to measure exposures during the actual military operations, the variable roles and job titles while serving in combat, and the fact that military service members are reluctant to report symptoms while deployed and in active-duty service. However, it is possible there is a greater prevalence of sarcoidosis in military deployers than non-deployers like the increased prevalence of sarcoidosis in firefighters who responded to the WTC disaster site compared to those that did not. Attribution of the development of sarcoidosis to Southwest Asia deployment cannot be made based on the data presented in this case series.

The PACT (Providing Access to Care for Veterans) Act was established with the aims of increasing veterans' access and coverage of care related to conditions stemming from toxic exposures during their military service time (24). It was amended on August 10th, 2022 to increase disability compensations, expand presumptive locations and additional conditions associated with burn pits and other toxins, including sarcoidosis and other interstitial lung diseases (24). Benefits and coverage stemming from this funding became available in January of 2023, which was after the search and analysis of this study cohort was completed. It serves as further incentive for future investigations given that a larger number of patients with previously undiagnosed or untreated sarcoidosis is likely to be officially recognized and followed clinically.

Conclusions

Our study suggests that the sarcoidosis in military deployers to Southwest Asia and Afghanistan can be diagnosed many years after deployment. Further prospective, longitudinal studies which include a control group are needed to confirm our findings and determine if Veterans have unique patterns of sarcoidosis involvement.

Abbreviations: ACCESS: A Case Controlled Etiologic Study of Sarcoidosis; DLCO: Diffusion Capacity of the lung for carbon monoxide; FEV1: Forced expiratory volume in 1 second; FVC: Forced vital capacity; PFTs: Pulmonary function tests; PM: Particulate matter; WASOG: World Association of Sarcoidosis and Other Granulomatous Disorders; WTC: World Trade Center.

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