

Magnetic Resonance Imaging of the Lung as an Alternative for a Pregnant Woman with Pulmonary Tuberculosis

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ABSTRACT

We report a case of a pregnant 21-year-old woman with pulmonary tuberculosis in which magnetic resonance imaging of the lung was used to assess the extent and characteristics of the pathological changes. Although the lung has been mostly ignored in magnetic resonance imaging for many decades, today technical development enables detailed examinations of the lung. The technique is now entering the clinical arena and its indications are increasing. Magnetic resonance imaging of the lung is not only an alternative method without radiation exposure, it can provide additional information in pulmonary imaging compared to other modalities including computed tomography. We describe a successful application of magnetic resonance imaging of the lung and the imaging appearance of post-primary tuberculosis. This case report indicates that magnetic resonance imaging of the lung can potentially be the first choice imaging technique in pregnant women with suspected pulmonary tuberculosis.

CASE REPORT

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Clinical presentation

A 21-year-old woman was referred to our hospital from a refugee camp with a two-week history of progressive dyspnea and fever. She had recently fled from Sudan. Pregnancy at week 25 was known. Her clinical condition was poor. Initial laboratory findings were leukocytosis ($11.9 \times 10^9/l$ [$3.9 - 10.2 \times 10^9/l$]), erythropenia ($3.5 \times 10^{12}/l$ [$3.9 - 5.15 \times 10^{12}/l$]), low hemoglobin (100 g/l [120 - 154 g/l]), low hematocrit (30 % [35.5 - 45.0 %]) and high C-reactive protein (80.9 mg/l [< 1.0 mg/l]). Several serological tests revealed no viral infection, especially no human immunodeficiency virus (HIV). Pneumonia was the presumptive clinical diagnosis. A chest X-ray in posterioranterior view was performed for further

diagnosis. Because of the known pregnancy no lateral view was obtained to keep the radiation exposure as low as possible.

Imaging findings

The X-ray showed extensive air-space consolidations with air bronchogram in the upper fields, predominant on the right side. The right hemidiaphragm was elevated. No cavities within the consolidations, no pleural effusion and no mediastinal lymphadenopathy were clearly detectable (Fig. 1). Together with the clinical history post-primary pulmonary tuberculosis was the presumed diagnosis.

Management

The patient underwent bronchoscopy which revealed mild bronchitis with swelling of the upper lobe ostia on the right

side. Sputum, bronchoalveolar lavage fluid and blood were taken for diagnosis of tuberculosis but smear microscopies, cultures and interferon- γ -release assays were negative. These findings were considered as inconsistent with the suspected diagnosis of post-primary pulmonary tuberculosis. During one week of therapy with tazobactam the high level of C-reactive protein remained stable and symptoms aggravated. A follow-up investigation, preferably cross-sectional imaging, was requested. To spare the pregnant woman from additional radiation exposure, a magnetic resonance imaging (MRI) scan instead of a chest X-ray or computed tomography (CT) scan was performed. Images were acquired on a 1.5 Tesla scanner (Magnetom Avanto, Siemens Healthcare, Erlangen, Germany). To keep the examination time short, only two sequences were carried out: axial T2-weighted turbo spin-echo 4mm, echo time 73ms, repetition time 6800ms and coronal T1-weighted volume interpolated gradient-echo 2mm, echo time 1.6ms, repetition time 4.1ms, flip angle 10°. Parallel imaging with an acceleration factor of 2 was used in both sequences. No fat saturation was used and no contrast medium was administered. Images were acquired during breath-holds in inspiration and although the patient was short of breath she was able to follow the breathing instructions without difficulties. No electrocardiographic or respiratory gating were used. The in-room time including patient positioning and planning was 7 minutes with a total scan time of 150 seconds.

Imaging findings

The images showed extensive air-space consolidations with air bronchogram and multiple, air-filled cavities with a maximum size of 13x18x11mm in both upper lobes, predominant on the right side (Fig. 2 and 3). The consolidations appeared inhomogeneous on T1- and T2-weighted images. On T1-weighted images their signal intensity was about isointense to muscle (Fig. 2) and on T2-weighted images slightly hyperintense to muscle (Fig. 3). Normal lung showed no visible signal and thus the consolidations appeared with strong inherent contrast and were easily detectable. Small fluid-levels isointense to cerebrospinal fluid could be seen on the T2-weighted images in some of the cavities. Smaller lobular air-space consolidations could be found in the middle lobe and in both lower lobes as a sign of a bronchogenic dissemination of the disease. Thickening and high signal intensity of the bronchial walls indicated bronchial wall edema (Fig. 3). Coronal T1-weighted images demonstrated a partial atelectasis of the middle lobe and an elevation of the right hemidiaphragm (Fig. 2). No mediastinal lymphadenopathy and no pleural effusion were detectable. All findings confirmed the presumed diagnosis of post-primary pulmonary tuberculosis.

Management

A second bronchoscopy was performed and again only a mild bronchitis with swelling of the upper lobe ostia on the right side was found. However, a culture for Mycobacterium tuberculosis grown from sputum became positive and with this finding, pulmonary tuberculosis was proven. Drug susceptibility testing was done and no resistances were found. A therapy consisting of isoniazid, rifampicin, pyrazinamide and ethambutol for two months followed by rifampicin and isoniazid for four months was initialized.

Follow-up

Under therapy, symptoms quickly improved and the patient was discharged. In the course of outpatient treatment sputum smear microscopies and cultures were negative. At week 39 of pregnancy the woman spontaneously delivered a healthy full-term infant. There was no pathological evidence for mycobacterial infection of the placenta.

DISCUSSION

MRI of the lung has initially been applied almost three decades ago and after many years of development it is now starting to enter the clinical arena. It is already applicable in clinical practice and the number of indications is increasing. Compared to other modalities the absence of radiation is not the only advantage: MRI has several advantages including the ability to identify tissue characteristics and to apply an increasing spectrum of functional imaging techniques, such as perfusion assessment and the measurement of ventilation and respiratory mechanics [1]. In our case MRI of the lung was used in the diagnostic process of tuberculosis in a pregnant woman. Chest X-ray and CT are the first choice imaging techniques and play an essential role in diagnostics because they provide valuable information at an early stage [2]. Both entail radiation exposure and thus their application can be limited in pediatric patients, young adults or pregnant women as in our case. The embryo and fetus are particularly sensitive to ionizing radiation. According to European or American national guidelines chest X-ray and CT can be performed in pregnant women if the indication is serious [3, 4]. Health consequences for the embryo and fetus are considered as unlikely, since the uterine exposure is very low with modern imaging techniques [3, 4]. However we decided to spare the woman and the fetus from additional radiation exposure by performing MRI of the lung. A study from 2011 indicates that MRI of the lung can achieve a diagnostic performance comparable to CT in the diagnosis of pulmonary tuberculosis [5]. Although we used a different examination technique and protocol compared to this study; the pathological findings of post-primary pulmonary tuberculosis could be displayed in detail.

Etiology & Demographics

Tuberculosis is an infectious disease caused by Mycobacterium tuberculosis that predominantly affects the lung [6]. It is transmitted by the inhalation of infectious aerosol droplets expelled from persons with pulmonary tuberculosis by coughing or sneezing [2, 6]. Although the estimated absolute number of tuberculosis cases worldwide has been slightly decreasing since a peak in 2004, it remains on a high level with 8.6 million new cases in 2012 [7]. The majority of cases occur in Africa with an estimated incidence of 255 per 100,000 and in southeast Asia with an estimated incidence of 187 per 100,000 in 2012 [6, 7]. Tuberculosis is more frequently diagnosed in men than in women with a male:female ratio of 1.7:1 [7]. 55% of all new cases are aged 15-44 years [7]. There is a strong association between tuberculosis and HIV-infection [6, 7].

Clinical & Imaging findings

Common symptoms in patients with pulmonary tuberculosis are dyspnea, productive cough, hemoptysis and chest pain. Additional signs of the infection are fever, chills, night sweats, loss of appetite, weight loss and fatigue [6]. The patient in our case showed comparatively mild and unspecific symptoms. The definite diagnosis is made by directly detecting *Mycobacterium tuberculosis* in a culture grown from a patient specimen, commonly sputum, bronchoalveolar lavage fluid or tissue. Sputum smear microscopies, interferon- γ -release assays and tuberculin skin tests are also usually performed and can give strong clues [2, 6]. All tests for tuberculosis were initially negative in our case and thus other differential diagnoses were considered. The culture grown from sputum took two weeks to become positive.

We used MRI of the lung with T1- and T2-weighted sequences to assess the extent and characteristics of the pathological changes of the disease. With MRI the imaging features of post-primary pulmonary tuberculosis including upper lobe predominant involvement, extensive air-space consolidations with bronchogram, air-filled cavities with fluid levels, smaller lobular consolidations and edema in thickened bronchial walls could be displayed in detail [8, 9]. The lack of lymph node involvement or pleural effusions is a common finding in post-primary tuberculosis. Except extensive air-space consolidations these findings could not clearly be detected with conventional chest X-ray and thus the diagnostic value of MRI was much higher. With MRI of the lung not only extensive air-space consolidations can be detected. The method is also suitable for the detection of smaller lobular air-space consolidations and even of the "tree in bud"-pattern, which is often considered as a hallmark for tuberculosis [5]. Since the image quality was excellent in our case by using the breath-hold technique, although the patient was short of breath, we experienced that the use of electrocardiographic or respiratory gating is not mandatory. However, in non-cooperative patients or patients with severe dyspnea breathing artifact issues can certainly make the examination impossible. We only applied a T1- and a T2-weighted sequence because we wanted to keep the examination time as short as possible. The role of other sequences like diffusion weighted imaging in infectious diseases is a topic for further studies.

Treatment & Prognosis

According to the recommendations included in the World Health Organization guidelines for the treatment of tuberculosis drug susceptibility testing should ideally be done for all patients at the start of the treatment [10]. The standard first-line treatment regimen consists of two months of isoniazid, rifampicin, pyrazinamide and ethambutol followed by four months of rifampicin and isoniazid, each in one daily dose. In pregnancy a successful treatment with the standard regimen is important for a successful outcome. The drugs used in the first-line regimen are safe in pregnancy [10]. Tuberculosis is a curable disease with good prognosis if it is diagnosed early and fully treated. If mycobacteria remain in the body the infection can relapse.

Differential Diagnoses

Pulmonary tuberculosis can be difficult to differentiate from other types of pneumonia or cancer [8]. Necrotizing pneumonia caused by *Staphylococcus aureus* commonly presents with extensive air-space consolidations and cavities. It does not predominantly affect the upper lobes and lymph node involvement and pleural effusion are more common [8]. Necrotizing pancoast tumors can mimic the appearance of post-primary pulmonary tuberculosis. These tumors frequently metastasize into mediastinal lymph nodes and infiltrate the chest wall [8]. Knowledge of the imaging appearance of post-primary tuberculosis as described in this case report together with the clinical history helps to make the right diagnosis.

In conclusion, this case report indicates that MRI of the lung can potentially be the first choice imaging technique in pregnant women with suspected pulmonary tuberculosis and provide a higher diagnostic accuracy compared to chest X-ray in a stage where other tests are not yet positive.

Generally MRI of the lung is a developing field with increasing indications and should be considered more in clinical practice. Its use is not only limited to pediatric, young or pregnant patients. MRI of the lung can provide complementary information in the diagnosis of pulmonary diseases like lung cancer, cystic fibrosis, sarcoidosis or acute and chronic pulmonary embolism [1]. The limited availability of modern scanners and the higher costs compared to chest X-ray and CT are potential downsides of the method. However, in pregnant women there is a remaining risk of causing harm to the fetus by the application of radiation and this may be associated with much higher costs for treatment in the future. Although we could show that MRI of the lung can be performed quickly, chest X-ray and CT are usually performed faster. Furthermore breathing artifacts can be an issue and, as known from MRI examinations of other parts of the body, MRI is difficult in claustrophobic, non-cooperative patients and patients with metal implants. In the event of infectious patients, such as in the reported case, the scanner and the room have to be disinfected after the examination. This can be more difficult in MRI since the disinfectant has to be familiar with the requirements of this environment.

TEACHING POINT

Magnetic resonance imaging of the lung is a promising technique with increasing indications which is now starting to enter the clinical arena. Magnetic resonance imaging of the lung can potentially be the first choice imaging technique in pregnant women with suspected pulmonary tuberculosis and display the imaging features of the disease including upper lobe predominant involvement, extensive air-space consolidations with bronchogram, air-filled cavities with fluid-levels, bronchogenic dissemination, and airway involvement in detail.

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FIGURES

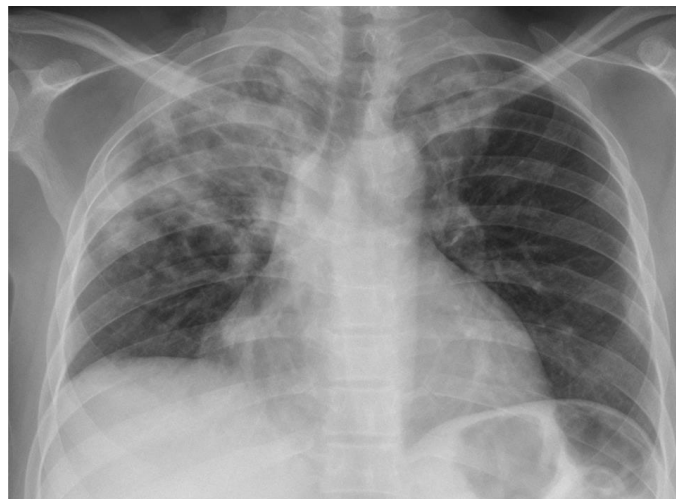


Figure 1: 21-year-old woman with post-primary pulmonary tuberculosis. Findings: Chest X-ray demonstrating extensive air-space consolidations with bronchogram in both upper fields, predominant on the right side. The right hemidiaphragm is slightly elevated. Technique: 125kV, 1,1mAs. Dose area product 5.19 cGy * cm².

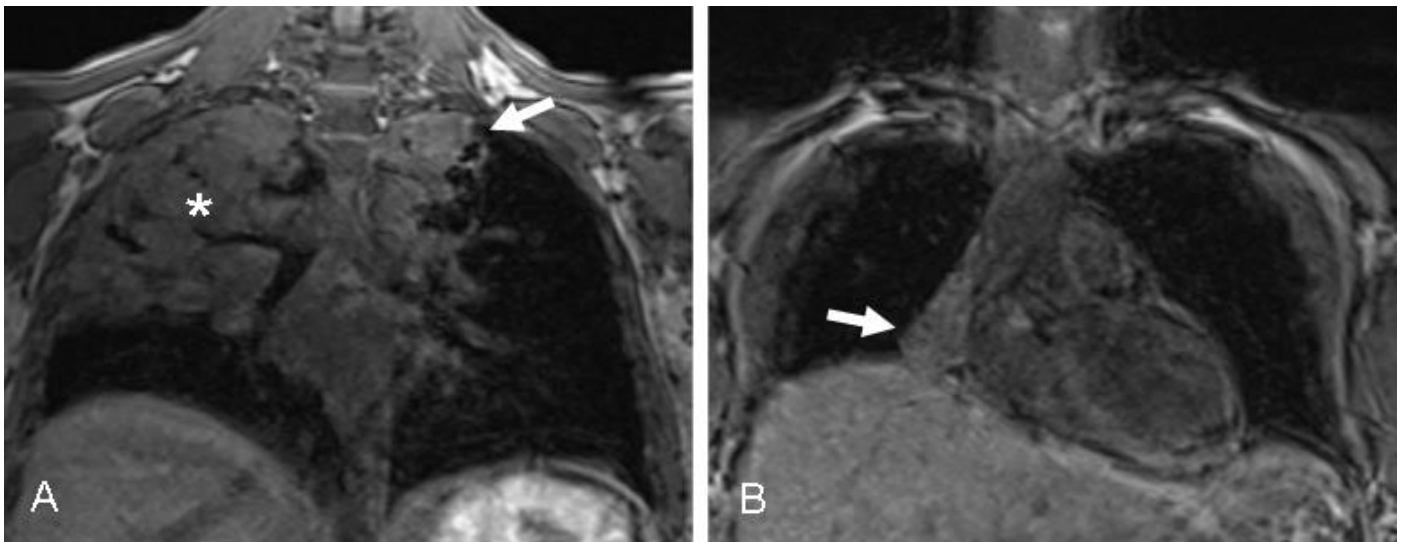


Figure 2: 21-year-old woman with post-primary pulmonary tuberculosis. Findings: Coronal T1-weighted images demonstrating extensive consolidations with bronchogram in both upper lobes (asterisk in (A)) and an atelectasis of the middle lobe (arrow in (B)). Technique: 1.5T, 2mm slice thickness, echo time 1.6ms, repetition time 4.1ms, flip angle 10°, no contrast medium.

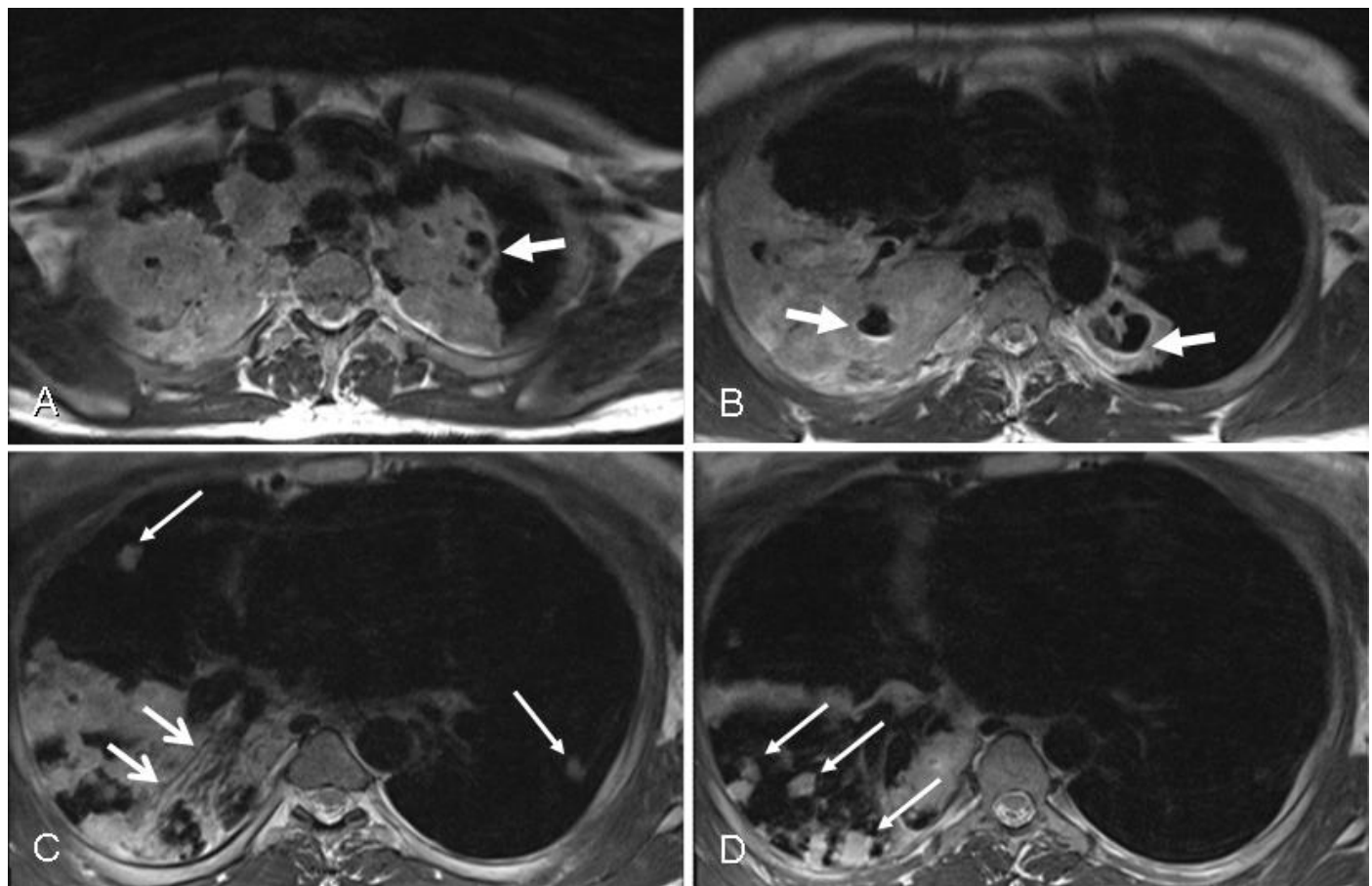


Figure 3: 21-year-old woman with post-primary pulmonary tuberculosis. Findings: Axial T2-weighted images demonstrating caverns with a maximum size of 18x13x11mm inside the consolidations without fluid levels (arrow in (A)) and with small fluid levels (arrow in (B)). Bronchogram, edema of the bronchial walls (open arrow in (C)) and smaller lobular consolidations (long arrows in (C) and (D)). Technique: 1.5T, 4mm slice thickness, echo time 73ms, repetition time 6800ms.

Etiology	Infectious disease caused by Mycobacterium tuberculosis. Transmission by inhalation of infectious aerosol droplets expelled from persons with pulmonary tuberculosis.
Incidence	Incidence rates strongly vary depending on the region with the highest numbers in Africa with 255 per 100 000 in 2012.
Gender ratio	Worldwide male:female ratio is 1.7:1.
Age predilection	55% of all new cases were aged 15-44 years.
Risk factors	Contact with persons with pulmonary tuberculosis. HIV.
Treatment	The standard first-line treatment regimen consists of two months of isoniazid, rifampicin, pyrazinamide and ethambutol followed by four months of rifampicin and isoniazid, each in one daily dose.
Prognosis	The disease is curable. The prognosis is good, if fully treated.
Imaging findings	Extensive air-space consolidations with bronchogram, air-filled cavities with fluid-levels predominant in the upper lobes, bronchogenic dissemination and bronchial wall edema.

Table 1: Summary table of pulmonary tuberculosis.

	X-ray	CT/MRI
Post-primary pulmonary tuberculosis	Upper lobe predominant extensive air-space consolidations. Cavities can be difficult to detect.	Upper lobe predominant extensive air-space consolidations with cavities, bronchogenic dissemination and airway involvement. Atelectases may be present. Lack of mediastinal lymph node involvement and pleural effusion is a common finding.
Necrotizing pneumonia	Extensive air-space consolidations. Cavities can be difficult to detect. Widening of the mediastinum and pleural effusion may be present.	Extensive consolidations with cavities. Mediastinal lymph node involvement and pleural effusion may be present.
Pancoast tumor	Apical mass or consolidation. Cavities can be difficult to detect. Widening of the mediastinum and pleural effusion may be present.	Apical mass. Cavities, chest wall invasion, mediastinal lymph node metastases and pleural effusion may be present.

Table 2: Differential diagnosis table for post-primary pulmonary tuberculosis.

Stage	Cross-sectional imaging features
Primary tuberculosis	<ul style="list-style-type: none"> • Small segmental, lobar or multifocal consolidation. • Atelectasis. • Lymphadenopathy with peripheral contrast enhancement and central necrosis.
Progressive primary tuberculosis	<ul style="list-style-type: none"> • Progressive consolidation possibly with cavities. • Signs of bronchogenic dissemination and airway involvement including lobular consolidations, bronchial wall thickening and the “tree in bud” pattern.
Post-primary tuberculosis	<ul style="list-style-type: none"> • Upper lobe predominant extensive consolidations. • Cavities with fluid levels. • Bronchogenic dissemination and airway involvement including lobular consolidations, bronchial wall thickening and the “tree in bud” pattern. • Lymphadenopathy and pleural effusion are possible but uncommon.
Inactive/healed up infection	<ul style="list-style-type: none"> • Calcified tuberculoma (Ghon’s complex). • Calcified tuberculoma and calcified hilar lymph nodes • (Ranke’s complex).
Miliary tuberculosis (complication)	<ul style="list-style-type: none"> • Profuse, well defined, disseminated small nodules.

Table 3: Cross-sectional imaging appearances of the different stages of pulmonary tuberculosis.

ABBREVIATIONS

CT = computed tomography
 HIV = human immunodeficiency virus
 MRI = magnetic resonance imaging

KEYWORDS

MRI; lung; tuberculosis; pneumonia; pregnancy

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