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## Case Report

# Preventing aspiration incidents: redesigning inhalers for enhanced safety: A case study of coin aspiration ☆☆☆

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## ABSTRACT

The conventional metered dose inhaler (MDI) has long served as a cornerstone in the management of asthma and chronic obstructive pulmonary disease (COPD), affecting millions annually. Despite its advantages, a persistent challenge is seen in the form of patient education and the unchanged design of these inhalers since their inception in 1956. This lack of progress in MDI design has inadvertently contributed to incidences of foreign body inhalation. In this case presentation we report a 50-year-old male with a past medical history of asthma, who faced an incident of foreign body inhalation with use of his inhaler. The patient aspirated a dime when he administered his inhaler, as it had become lodged in the device's mouthpiece, which was uncapped. This case, like many others, demonstrates the need for innovative changes in MDI inhaler design. While numerous articles or cases concentrate on foreign body removal, the primary objective of this case report is to investigate preventative measures and solutions aimed at averting incidents of inhalation.

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## Introduction

Patients suffering from asthma and chronic obstructive pulmonary disease (COPD) represent a large portion of the United

States population, with an annual total of around 40 million [1,2]. The cornerstone of treatment for both conditions involve the use of inhalers to manage both daily symptoms as well as acute exacerbations. However, 1 of the barriers to the successful management of these diseases is the lack

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of patient education and training regarding the use of these devices. The initial design for the inhaler was conceived in 1956 by George L. Mason of Riker Pharmaceuticals, now known as 3M. Inspired by his 13-year-old daughter's struggle with Asthma and the challenges associated with medication administration, he directed his company towards creating the now widely used metered dose inhaler (MDI) [3]. The design of the modern MDI has been largely unchanged since the initial Riker design. This case underscores the necessity for revisiting the design of such devices, with the aim of ensuring their safe and cost-effective use by patients. It emphasizes the importance of continuous improvement in medical device design to enhance patient safety and treatment efficacy.

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### Case report

A 50-year-old male patient with a history of asthma, managed by his primary care physician, was admitted to the hospital following a sudden onset of dyspnea. His past medical history includes asthma, hypertension (HTN), gout, type II diabetes mellitus (T2DM), hyperlipidemia (HLD), and iron deficiency anemia (IDA). Despite the absence of wheezing, his air movement was noticeably restricted over the right side of his chest. All laboratory test results and vital signs were within the normal limits. During his stay in the emergency department, a chest X-ray (CXR) and computed tomography (CT) scan was conducted, revealing a round, slender object, presumed to be a coin, situated just above the carina, inclined towards the right main stem bronchus (Figs. 1 and 2). Upon identification of the foreign object, an urgent bronchoscopy was planned

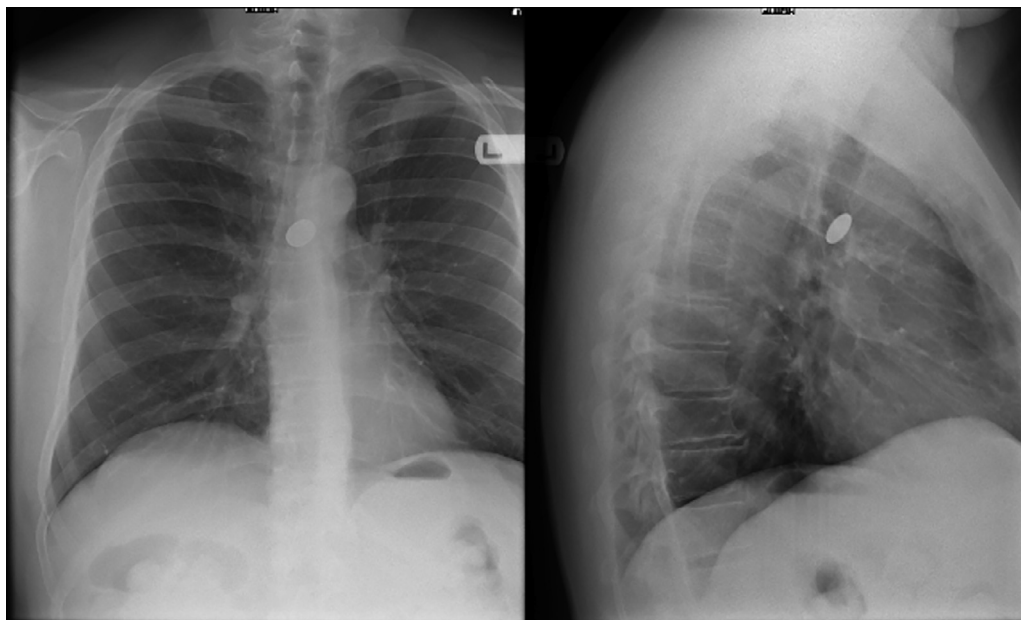
to extract the coin and alleviate the obstruction. The patient was subsequently transferred to the operating room, where anesthesia was administered prior to the procedure. The initial strategy entailed a bag retrieval following the placement of a laryngeal mask airway. However, despite best efforts, this approach proved unsuccessful, necessitating the use of a trigger grasp. This adjusted technique successfully facilitated the extraction of a United States Dime (Fig. 3). The patient experienced immediate relief and significant improvement in his breathing.

Further investigation revealed that the patient had aspirated the coin while using his inhaler during the initial onset of dyspnea. Unbeknownst to him, a dime had been lodged in the mouthpiece of his uncapped inhaler, leading to the accidental aspiration when he administered the medication. Postprocedure, the patient was discharged home without any complications. However, the incident caused considerable emotional distress and instilled a lasting hesitancy towards using his rescue inhaler.

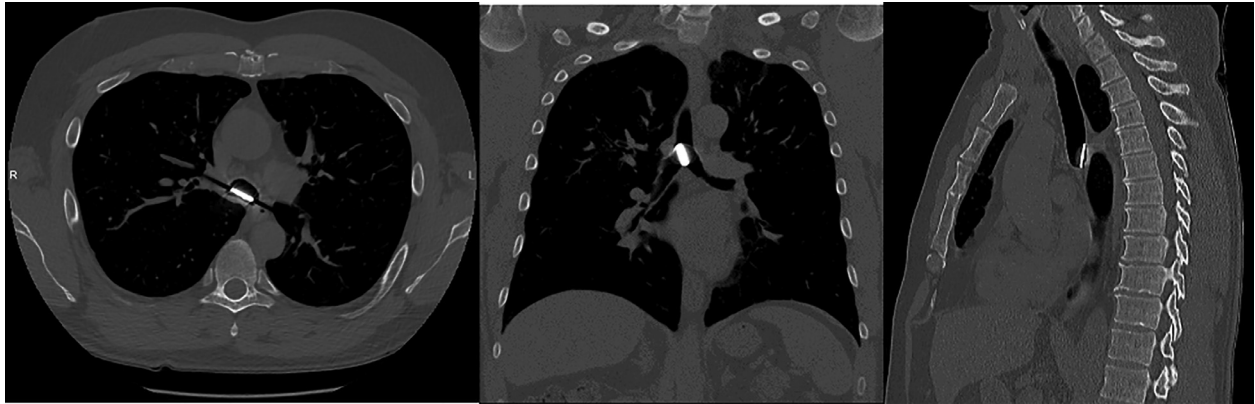
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### Current design

MDI's currently use an active drug mixed in a solution with a solvent and a surfactant chemical. These are mixed into a delivery vehicle (often a pressurized canister) and the patient is able to self-administer the therapy after training [4]. With the increased focus on environmental health, a push is being made to move away from these pressurized canisters to reduce ozone decaying chemicals. The medical field has been exempting from these environmental regulations to keep the cost of production down for patients. However, there is an expectation of change within the industry. This desire to be



**Fig. 1** – This figure depicts the anterior-posterior, posterior-anterior, lateral chest X-ray: 2 × 2 × 0.2 cm well-circumscribed hyperdense structure against the posterior surface of the distal trachea and projecting over the region of the carina. Most likely representing an aspirated foreign metallic object. No signs of lung collapse.



**Fig. 2** – This figure depicts the axial, coronal, sagittal CT scan noncontrast; bone window: Outer Ring attached to the foreign body suggesting that this metallic structure could represent a round watch battery. Distal airways remain patent.



**Fig. 3** – Endoscopic imaging showing retrieval of the coin within the trachea clipped with a serrated clip rather than a smooth clip. Post procedure removal of the foreign body.

more environmentally friendly may provide a good opportunity to implement changes to the industry standard. The current safety measure includes a removable cap which slides over the mouthpiece [3,5].

This current safety standard may be one of the simplest designs, however there is a potential for human error. Patients often lose the cap, or forget to use it. Multiple cases have been reported in literature with the root cause being user error due to lack of inhaler cap. Blake, Lucinda Katharine McCowan et al. reported a case of a 41-year-old female at a new year's eve party when she urgently needed to use her inhaler. Her uncapped albuterol rescue inhaler had a heart shaped earring inside the mouthpiece which she aspirated causing a very similar presentation to our patient. Endobronchial retrieval was required to clear the subtotal obstruction [6]. As reported in multiple previous reports, similar cases with small objects such as pennies, 5 pence coins, and plastic cable slip covers have been aspirated [7–9]. In all of the above cases reported, a common denominator was the lack of inhaler cap preventing foreign objects being wedged in the mouthpiece area.

## Discussion

Inhalers are oftentimes the mainstay treatment for millions of patients in the US and worldwide. There have been a few updates to the safety design since its initial introduction in the 50s. A large number of inhalers still utilize the same overall design and have not undergone many changes. The biggest push in updating inhaler designs revolve around the ability to administer a larger dose in a quicker time span to help expand the scope of diseases an inhaler could be used for [10].

When exploring possible ways to mitigate accidental aspirations, an alternate design of the mouthpiece should be considered. All-in-one designs are oftentimes preferred for both simplicity and durability. Two potential alternatives include either a gated, or a cross weaved mouthpiece. Some of the newer inhaler designs from brand name manufacturers utilize a sliding gated mouthpiece already. Unfortunately, one of the most frequently used inhalers which patients incur complications from are the generic albuterol formulation inhalers.

Both of these design changes can prevent accidental aspirations from occurring, while maintaining a simple to use safety system. The cross weaved design's major limitation is the potential for trapping medication on the backside of the thatching, leading to buildup and ultimately clogging of the opening. This should be taken under consideration with the introduction of new aerosol formulations that have an increased viscosity.

In addition to design changes, it will still be important to reiterate proper inhaler technique with current inhalers, as well as any new designs. With the market expanding and MDI's being utilized for a number of different diseases, confusion between different designs will lead to inadequate utilization. Providing hands on training and re-enforcing proper technique can help mitigate accidental aspirations as well as other potential complications.

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## Conclusion

The authors of this case presentation report a preventable coin aspiration in a 50-year-old male with multiple comorbidities. The authors review the current inhaler designs and discuss 2 proposed designs both require little to no patient engagement to operate correctly. All inhalers should incorporate improved safety features especially as the incidence and prevalence of Asthma or COPD increases, and inhalers are a mainstay of treatment. This case highlights the ongoing problem with current inhaler designs.

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## Patient consent

We would like to confirm that the case information in this manuscript titled "Preventing Aspiration Incidents: Redesigning Inhalers for Enhanced Safety – A Case Study of Coin Aspiration" has been provided with informed consent from the patient presented. The patient has given permission to appear in the case information in the print, online, and licensed versions

of a medical journal. The patient has been offered the opportunity to read the general description of what this manuscript contains and review all the included photographs of the investigations done and submitted for publication.

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