BENDING THE VALUE CURVE

Not Everything That Wheezes Is Asthma, but Most Is: Remembering Occam's Razor

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"Frustra fit per plura quod potest fieri per pauciora."
"It is futile to do with more things that can be done with fewer."
W. M. Thorburn, "Occam's razor," Mind, *24, pp. 287–288, 1915.*

CASE PRESENTATION

A 17-year-old girl with a history of asthma and anxiety presented to a community hospital emergency department (ED) with difficulty breathing and wheezing. Since onset of symptoms 2 days ago, she has been using albuterol every 4 hours. Her pediatrician diagnosed an asthma exacerbation and prescribed oral prednisone. On the morning of admission, her symptoms worsened, and she developed increased work of breathing, wheezing, difficulty speaking, and left-sided chest pain.

In the ED she was noted to be in moderate respiratory distress, with peripheral oxygen saturation ($Sp0_2$) of 92%, tachycardia, tachypnea, and a normal blood pressure (Fig 1). She received albuterol and intravenous methylprednisone. A chest radiograph showed patchy retrocardiac opacities, blood cultures were drawn, and she received ceftriaxone and azithromycin for presumed pneumonia. An arterial blood gas (ABG) showed pH 7.43, $Paco_2$ of 28.9 mm Hg, and $Pa0_2$ of 67 mm Hg. Because of concern for low $Pa0_2$ and chest pain, a computed tomography pulmonary angiogram (CTPA) was performed and interpreted as follows: "Questionable subtle filling defects seen at right lower lobe pulmonary arterial branches, subtle peripheral right lower lobe pulmonary emboli are suspected—no additional larger central pulmonary arterial filling defects are seen." She was transferred to our PICU because of concern for PE and possible need for anticoagulation. In the PICU she was found to be in mild to moderate respiratory distress, significantly improved from earlier in the day. She continued to receive steroids, albuterol, and antibiotics but did not need supplemental oxygen. After a careful analysis of risks and benefits, we decided not to initiate anticoagulation therapy. However, in consultation with a pediatric hematologist, a hypercoagulability workup was ordered.* All results were normal or negative. Her chest pain resolved within a few hours. She was transferred to acute care within 24 hours and discharged from the hospital in 48 hours.

In summary, a teenager with a history of asthma and anxiety presented to medical care with symptoms of asthma and anxiety. However, in addition to therapy for asthma, she underwent an expensive, painful, and hazardous workup for

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*Hypercoagulable workup included the following tests: protein C, protein S, antithrombin III, PROT 20210A, factor V Leiden, and methylenetetrahydrofolate reductase.

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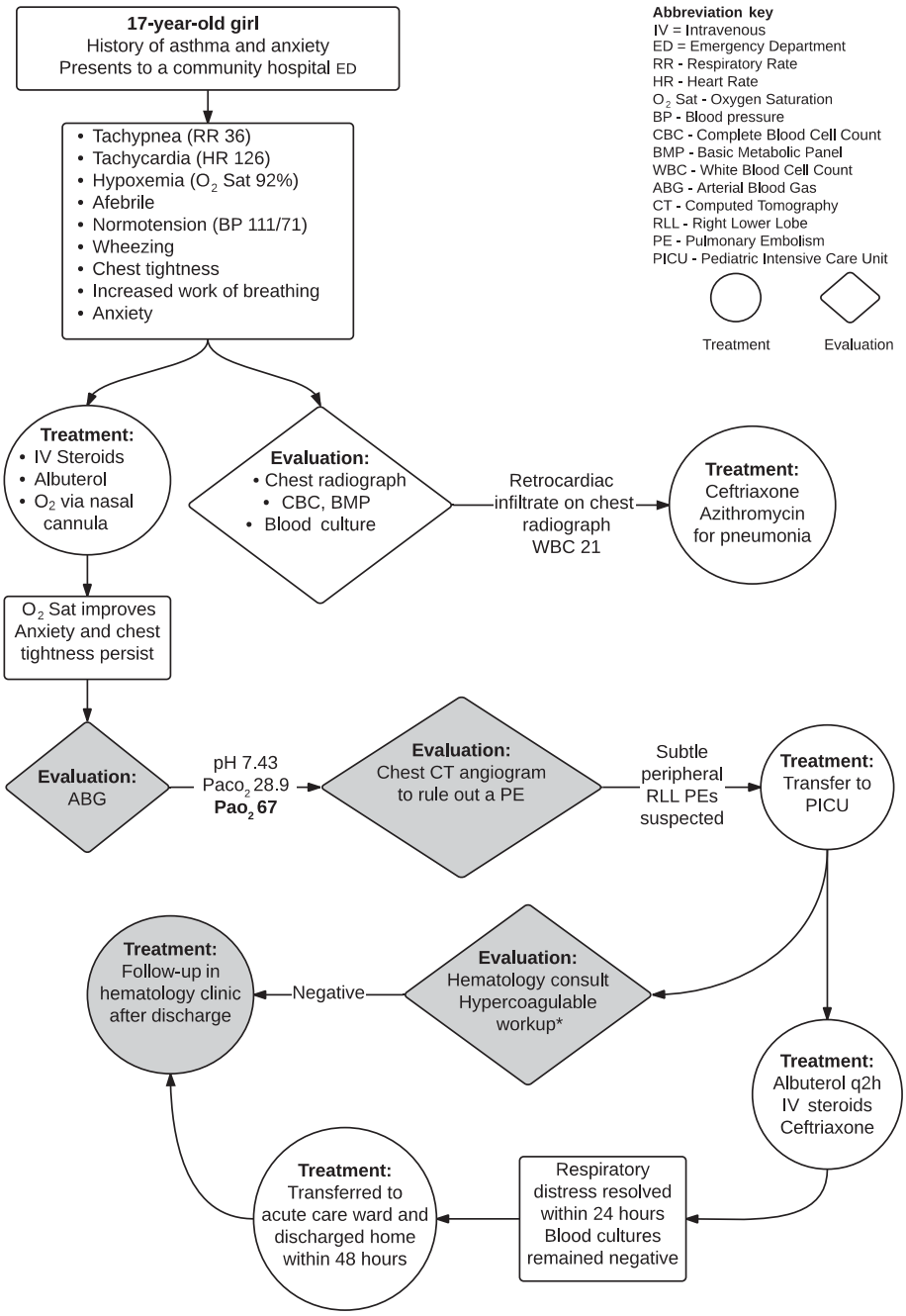

FIGURE 1 Evaluation and treatment sequence for a 17-year-old girl presenting with wheezing, chest pain, and shortness of breath.

PE and a hypercoagulability disorder. This case illustrates how 1 simple test, such as an ABG, performed without a clear indication, leads to interpretation errors and a cascade of subsequent studies, which in turn prompt unnecessary radiation exposure, a costly laboratory workup, an admission to an ICU, and a great deal of anxiety for the patient and her family (Fig 1, Table 1). The following discussion examines the evidence behind the management of this patient and an analysis of the value of the care she received.

WHY GET AN ABG?

There is no documented explanation for why an ABG was performed, but presumably it was done out of concern for inadequate alveolar ventilation. The first question is whether blood gas analysis was indicated. Many children with moderate to severe asthma have blood gas abnormalities on presentation to the ED. However, it rarely affects medical management and thus is not recommended routinely as part of the initial ED workup.[1] Whether $Paco_2$ on presentation is low or high, the strategy is the same: aggressive treatment to achieve bronchodilation, reduce inflammation, and improve laminar airflow, all while avoiding intubation and mechanical ventilation.

TABLE 1 Avoidable Charges (National Averages) Associated With Our Patient's Hospital Encounter

Procedure	Charge (Range)
ABG	$60–107[22–24]
CTPA	$1900–5000[25]
PICU daily charge	$7211–9150[26,27]
Hypercoagulable workup: protein C, protein S, antithrombin III, PROT 20210A, factor V Leiden, and methylenetetrahydrofolate reductase	$1873[30] (data from 2001)
Hematology clinic follow-up (office visit, level 2, new patient)	$157[22]

In fact, the tools for asthma severity assessment in the ED such as the Pulmonary Index Score[2] rely only on clinical findings including respiratory rate, wheezing, inspiratory/expiratory ratio, accessory muscle use, and oxygen saturation and do not include blood gas analysis.

The second question is whether the ABG results were interpreted correctly. $Pa0_2$ of 67 mm Hg in this patient reflects an elevated alveolar–arterial gradient, as is often seen in asthma, but is appropriate for the degree of oxygen saturation (92%).[3]

WHAT IS THE PRETEST PROBABILITY OF A PE IN THIS PATIENT?

PEs are exceedingly rare in children and adolescents, with 1 study estimating an incidence of only 105 in 1 185 794 pediatric ED visits.[4] The risk factors associated with developing a PE in this population include BMI >25, oral contraceptive use, and history of previous thrombus without a PE[4] as well as recent surgery, systemic lupus erythematosus, thrombocytopenia, long-term oral glucocorticoids, and trauma.[5,6] Our patient's history was negative for all these risk factors.

Common symptoms of PE include dyspnea, pleuritic pain, cough, orthopnea, calf or thigh pain and swelling, wheezing, and hemoptysis,[7] but these symptoms are neither sensitive nor specific. Our patient had dyspnea, chest pain, cough, and wheezing, all of which are consistent with her most likely diagnosis of asthma exacerbation.

Several tools have been developed to detect clinically significant PEs while minimizing unnecessary testing for others. In hemodynamically stable patients pretest probability is approximated with the modified Wells criteria.[8] Our patient had a modified Wells score of 1.5 (for heart rate >100 beats per minute), which puts her in the "PE unlikely" category. The next step is to check a D-dimer, which is highly sensitive but not specific for PE and is most valuable when used in conjunction with a Wells score to identify high-risk patients who need imaging. ABGs are often abnormal in patients suspected of having a PE, but they are neither sensitive nor specific and are not included in the Wells score. A D-dimer was not sent on our patient, nor was there any documentation of estimated probability for a PE. Instead, the combination of chest pain and a borderline low $Pa0_2$ in a patient with no known risk factors prompted a CTPA.

DID WE FIND PEs THAT DID NOT NEED TO BE FOUND?

Enhanced CTPA protocols detect smaller emboli, the clinical relevance of which is unknown. Widespread availability of CTPA makes clinicians more likely to look for PEs. The incidence of PEs has increased by 80% since introduction of this technology in the United States, without any change in PE-associated age-adjusted mortality.[9] This increase suggests overdiagnosing: The PEs that are found are real, but their discovery does not benefit and may harm the patient. Interestingly, the age-adjusted case fatality of PEs has dropped by one-third, indicating that the extra PEs that are being discovered are less lethal.[9] The 2- to 3-mm filling defects in subsegmental arteries, which previously went unrecognized, may represent normal trapping of the small emboli formed in leg veins to prevent them from traveling to arterial circulation and causing strokes.[10] These emboli are believed to be clinically insignificant and are resorbed by the body without treatment.[10] This is probably what we saw on our patient's CTPA.

HAZARDS OF OVERIMAGING ARE NOT TRIVIAL

An estimated 20% to 50% of high-tech imaging procedures are unnecessary,[11] applied in cases where they are unlikely to change the course of treatment or improve patient outcome.

Radiation Exposure

Several alarming studies have concluded that neither physicians[12,13] nor patients[14] are well informed about the risk of carcinogenesis associated with computed tomography (CT) radiation, particularly in younger patients. The use of CT imaging in young people is not insignificant: 5% of 20-year-olds undergo CT imaging each year.[15] The value of information gained from these studies must be weighed against a small but real risk of cancer. Radiation exposure is especially worrisome in young women. For every 1000 20-year-old women who undergo a CTPA, 3 will develop cancer.[15] Combining CTPA, CT coronary angiography, and multiphase abdomen and pelvis CTs in 20-year-old women brings the associated risk of developing cancer to as high as 1 in 80.[15]

Incidental Findings

An estimated one-fourth of CTPAs detect an unexpected abnormality such as a pulmonary nodule, a thyroid nodule, or adenopathy.[16] Furthermore, CTPAs that are ordered in the ED are more than twice as likely to discover an incidental finding other than a PE.[16] Although most of these are false alarms, they often lead to additional testing and treatment.

Anticoagulation Therapy

Given the radiologist's report of PEs, some providers would have initiated prolonged anticoagulation in our patient. Anticoagulants are a leading cause of medication-associated morbidity in the

United States.[17] Not surprisingly, as more CTPAs are performed and more small subsegmental PEs are discovered, more anticoagulation therapy is administered, leading to a rise in anticoagulation-associated complications.[9] One study found that in patients with isolated subsegmental PEs, the risk of major bleeding associated with anticoagulation therapy was 5.3%, which is much higher than a 0.7% risk of a recurrent thrombus.[18]

THE "ASTHMONIA" DIAGNOSIS

Aside from the unnecessary PE evaluation, this case illustrates a more common example of potential overdiagnosis: a combined finding of asthma and pneumonia, leading to broad-spectrum antibiotic exposure. Our patient had no hard evidence of bacterial pneumonia. Her diagnosis and treatment were based on nonspecific chest radiograph and complete blood cell count findings, neither of which is recommended for routine asthma assessment.[1,28] The role of respiratory infections in asthma is beyond the scope of this discussion, but the diagnosis of "asthmonia" remains a common pitfall of high-value care.

LESSONS LEARNED

In the era of a rapidly growing arsenal of diagnostic and therapeutic choices we must strive to provide high-value medical care, which means achieving the best outcomes at the lowest possible cost and with the least amount of harm to the patient. This case illustrates several missed opportunities for providing high-value care, such as routine application of evidence-based guidelines, thoughtful risk estimation with the aid of decision support tools, and vigilant use of high-tech diagnostic modalities. It also reminds us not to search for alternative diagnoses when a condition is readily explained by a proximate one and to move past the inherent psychological biases associated with the uncertainty of doing less.

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