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## Editorial

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### Discussion of risk of scuba diving in individuals with allergic and respiratory diseases

Physicians are occasionally asked to certify that patients with asthma or other respiratory diseases may participate in scuba diving. Recent estimates suggest that there are 600,000 to 3,000,000 divers<sup>1</sup> who perform as many as 30,000,000 dives each year. At least 7% of the United States population has a diagnosis of asthma,<sup>2</sup> and some diving surveys indicate that 7% of divers consider themselves to have asthma.<sup>3</sup>

Whether there is any increased risk associated with asthma and diving is controversial. Approximately 500 to 600 cases of decompression sickness (DCS) or arterial gas embolism (AGE) are reported each year, constituting an overall risk for diving of 0.017% to 0.2%. It remains unclear whether patients with asthma or allergic disorders are overrepresented in these statistics.

Physiologic data suggest that active asthma should be an absolute contraindication to diving. Patients with asthma are at increased risk of pulmonary barotrauma and AGE, even in normal ascents without complications such as panic, out-of-air conditions, or breath-holding. Airway obstruction and decreased lung compliance have been associated with AGE.<sup>4,5</sup> Melamed et al.<sup>6</sup> have reviewed the physiologic consequences of

#### *Abbreviations used*

AGE: Arterial gas embolism  
DAN: Divers Alert Network  
DCS: Decompression sickness

diving and have discussed whether medical conditions, such as asthma, may predispose divers to have barotrauma, nitrogen narcosis, and DCS.

The complications associated with diving are related to the behavior of gases under the conditions of changing pressure during diving. Boyle's law states that at constant temperature, volume is inversely related to pressure. During ascent, gas within the lungs expands, and if a diver is unable to exhale properly, lung rupture may occur, resulting in pneumothorax, pneumomediastinum, or AGE. Barotrauma describes the injury that may result from failure to equalize internal pressures to changes in ambient pressure in a variety of organs such as the lungs, middle ear, and sinuses. With AGE, gas bubbles obstructing arteries may occlude blood flow in systemic vascular beds, resulting in a variety of consequences, the most severe of which may be neurologic or cardiovascular collapse and death. Those who survive may have severe disability.

Because of the potential severity of AGE, one authoritative source states: "Considering the potential catastrophic consequences of air embolism, it seems appropriate to recommend that asthmatics not dive."<sup>5</sup> This conservative view is not held by all diving authorities. In theory, patients with asthma should more frequently experience diving

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accidents. However, available data, although incomplete, do not confirm that asthmatic divers have more accidents.

Diving injuries associated with pneumothorax, AGE, or both occur more often for reasons other than asthma. The most common cause of lung overexpansion is a rapid or panicky ascent with breath-holding. Limiting the depth of the dive would not preclude this risk, because pressure changes are greatest at more shallow depths.

A number of attempts have been made to quantify the risk of pulmonary diving injuries in patients with asthma. In a survey of divers conducted in 1988, 1745 questionnaires were distributed and 443 were returned.<sup>3</sup> Thirty-one of the respondents reported a history of asthma. When questioned further, 19 of these asthmatic divers reported that they had made 100 dives without a case of AGE or DCS.

In 11 fatal diving accidents in New Zealand from 1981 to 1982, one subject had asthma.<sup>7</sup> The circumstances surrounding this single accident indicate that factors other than asthma played a role. A 1985 report suggests that only one of 39 cases of AGE could be attributed to a medical predisposition.<sup>8</sup> These limited data do not support the concept that asthmatic divers are at a significantly greater risk for AGE than the normal population.<sup>4</sup>

In a survey of divers in the United Kingdom,<sup>9</sup> 104 individuals who had performed 12,864 dives responded to a questionnaire addressed to asthmatic divers. No case of pneumothorax or AGE was reported. One diver had DCS on two occasions.

The Divers Alert Network (DAN), a national organization with headquarters at Duke University, reviewed accident data from 1987 to 1990. In 1213 cases of DCS, asthmatic divers constituted 16 of the 196 cases of AGE and 30 of the 755 cases of type II (more severe) DCS. Seven divers with AGE and 16 with type II DCS were said to have currently active asthma. A control group of 696 divers had no history of diving-related accidents. In this group, 37 subjects had a history of asthma and 13 had current symptoms of asthma with reactive airway disease. Odds ratio assessment of these data did not attribute an increased risk to asthma.<sup>10</sup> Therefore analyses of these DAN data do not demonstrate a greater risk for diving in those who self-reported asthma.

The DAN investigators subsequently surveyed asthmatic divers by questionnaire.<sup>11</sup> Two hundred seventy-nine questionnaires were returned, reporting 11 cases of DCS from a total of 56,334 dives. Eighty-eight percent of the individuals with asthma used medication for their reactive airway disease

and 55.8% took the medication before diving. Thirty percent had asthma symptoms either daily or weekly, and 26.4% had been hospitalized at least once for treatment of asthma. These data suggest that most of the individuals returning the questionnaires had ongoing airway inflammation. The calculated risk of DCS in these divers (1 in 5100 dives) significantly exceeds previous estimated risks in recreational divers with an odds ratio of 4:16.

If we accept the premise that asthma increases risk, is an increase in risk acceptable? When does the risk become too great? At present, divers who apply to be certified, to participate in lessons, or to take additional training require physician approval. Physicians aware of the available data regarding diving and asthma may be hesitant to approve these applications. Current data are inadequate, and the interpretation of these data is an area in which there is an honest difference of opinion among asthma care providers. Until the actual degree and nature of risk associated with asthma and scuba diving are clarified further by additional studies, the final decision to certify an individual to dive remains with the asthmatic individual and his or her physician.

Additional data from larger groups are required in order to allow a reasonable judgment concerning the severity and presence of asthma and its relationship to diving risks. Although the data are reassuring, they suffer from "healthy worker" bias because asthmatic individuals with moderate to severe disease may have self-selected themselves, avoiding diving altogether. Patients with mild or asymptomatic asthma nevertheless have considerable airway inflammation, particularly in smaller airways, and the possibility exists that diving risk persists even in patients with asymptomatic asthma. It is not clear whether patients with a history of asthma who have normal pulmonary function test results and a normal measure of bronchial hyperresponsiveness (negative methacholine, histamine, cold air, or exercise challenge results) would have an increased risk for complications associated with diving. It is also unclear whether any history of asthma should preclude diving. British investigators<sup>9</sup> suggest that diving should be prohibited within 48 hours of wheezing but do not indicate a need to monitor peak flow rates or comment regarding the degree of bronchospasm that would prohibit diving. If asthma is a risk factor for diving, an interval of 48 hours after the most recent episode of bronchospasm is insufficient time to allow normalization of airways.

Another concern regarding scuba diving is chronic or recurrent sinus or ear disease. Otologic and sinus problems are common sources of difficulty with diving. In fact, barotrauma of the middle ear and sinuses is the most common disorder in divers.<sup>12</sup> Because pressure changes across the tympanic membranes must equilibrate without difficulty during diving activities, otitis predisposes subjects to barotrauma. One recommendation is that otitis within the last 3 years should be an absolute contraindication to diving.<sup>13</sup> Individuals who have had tympanoplasty, middle ear surgery, perforation of the tympanic membranes, or other ear disease are at risk for injury when diving. A careful examination with special attention to the ability to autoinflate the middle ear and a normal tympanogram should be considered before approval for diving is given to individuals with middle ear disease. Those who have a history of ear surgery should have an ear, nose, and throat evaluation.

Individuals with nasal congestion from allergic rhinitis, which causes eustachian tube dysfunction, should be treated appropriately to decrease the nasal obstruction before approval for diving is given. The presence of sinusitis is also a relative contraindication to diving until the sinus disease is treated successfully. However, unlike complications related to airway obstruction, barotrauma to the sinuses rarely leads to life-threatening complications. The safety of either topical or systemic decongestants used before diving is unknown. These medications are commonly used by divers, particularly after recent upper respiratory tract illnesses, in order to establish adequate eustachian tube function.

The DAN, in reviewing various medically related areas and the risk of diving, states: "Ultimately, however, making the decision to accept risks involved in diving is each individual's responsibility."<sup>14</sup> Although, the final decision does remain with the individual who elects to dive, physicians also need to participate in this process by ensuring that patients are making an informed decision. Both patient and physician must consider the potential for serious consequences when an individual with asthma or allergic diseases participates in scuba diving.

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