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INNER EAR DECOMPRESSION SICKNESS (IEDCS) IN DIVERS

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Abstract (English)

Latar Belakang: Penyakit dekompresi telinga bagian dalam (IEDCS) adalah penyakit umum pada penyelam. Di Indonesia, IEDCS sering dialami oleh nelayan penyelam dalam memenuhi kebutuhan hidupnya. Secara umum, penyakit dekompresi (DCS) disebabkan oleh pembentukan gelembung gas di dalam pembuluh darah dan jaringan organ. Hal ini disebabkan oleh pengendapan gelembung gas di ruang endolymphatic dan perilymphatic selama proses naik ke permukaan dengan cepat.

Tujuan: Penelitian ini bertujuan untuk mengidentifikasi penyakit IEDCS pada penyelam.

Metode: Penelitian ini meggunakan pendekatan kuallitatif dengan model case study yang menganalisis dan mengidentifikasi gejala-gejala yang muncul pada penyelam yang menderita IEDCS.

Hasil: Gejala klasik IEDCS berkembang dalam waktu sekitar 30 menit dan bersifat vestibular, ini termasuk vertigo, ataksia, mual, dan muntah. Terapi pilihan yang dapat diberikan pada penderita DCS dan IEDCS adalah terapi oksigen hiperbarik (terapi rekompresi) dengan segera. Komplikasi jarang terjadi setelah terapi oksigen hiperbarik. Setelah terapi dan penderita DCS pulih, biasanya masih akan ada defisit sisa dalam keseimbangan dan pendengaran. Penyelaman yang sesuai protokol serta pemberian informasi mengenai DCS melalui edukasi, penyuluhan, atau media lain perlu dilakukan untuk kelompok beresiko agar tercipta pengetahuan yang memedai dan dapat melakukan pencegahan.

Kesimpulan: Penyakit dekompresi telinga bagian sering terjadi pada penyelam gas terkompresi. Hal ini disebabkan oleh pengendapan gelembung gas di ruang endolimfatik dan perilimfatik selama proses naik ke permukaan dengan cepat.

Kata kunci: IEDCS, dekompresi, penyelam, telinga bagian dalam

Abstract (English)

Background: *Inner ear decompression sickness (IEDCS) is a common disease in divers. In Indonesia, IEDCS is often experienced by diver fishermen in fulfilling their daily needs. In general, decompression sickness (DCS) is caused by the formation of gas bubbles in blood vessels and organ tissues. This is due to the deposition of gas bubbles in the endolymphatic and perilymphatic spaces during the process of their rapid rise to the surface.*

Objective: *This study aims to identify IEDCS disease in divers.*

Method: *This study used a qualitative approach with a case study model that analyzes and identifies the symptoms that appear in divers suffering from IEDCS.*

Result: *Symptoms of classic IEDCS develop in about 30 minutes and are vestibular, these include vertigo, ataxia, nausea, and vomiting. The preferred therapy that can be given to people with DCS and IEDCS is hyperbaric oxygen therapy (recompression therapy) immediately. Complications are rare after hyperbaric oxygen therapy. After therapy and DCS sufferers recover, there will usually still be residual deficits in balance and hearing. Diving according to protocol and providing information about DCS through education, counseling, or other media needs to be done for at-risk groups to create knowledge that is relevant and can take precautions.*

Conclusion: *The disease of decompression of the part ear is common in compressed gas divers. This is due to the deposition of gas bubbles in the endolymphatic and perilymphatic chambers during the process of rising to the surface quickly.*

Keywords: *IEDCS, decompression, diver, inner ear*

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INTRODUCTION

Scuba diving is an increasingly popular diving sport globally with around 1.2 million divers worldwide. At first, divers concentrated most of their dives only in warmer

coastal areas (Boyd KL WA, n.d.). But expansion in sports has expanded diving spots in other waters, including temperate and even polar seas, lakes, mines, and many others (Bove, 2014; Boyd KL WA, n.d.). This causes cases of diving-related disorders to appear in any hospital, whether inland or coastal. All doctors and medical emergency personnel should be aware of the signs and symptoms of decompression disease. In addition, all persons working in or associated with the risk of decompression should also understand this (Bove, 2014).

The inner ear consists of vestibulocochlear organs that are involved in the hearing and balance of a person. This organ is spiral in shape and is surrounded by an outer bone and contains a fluid called endolymph that is responsible for the conduction of sounds as well as perceiving changes in position (Scarpa et al., 2021; Whitfield, 2015). The cochlea is the part responsible for the conversion of mechanical sound waves into the action potential of the auditory nerve. The vestibular part consists of a utriculus, a sacculus, and a semicircular canal to modulate position and balance signals (Rozycki et al., 2018; Scarpa et al., 2021).

Inner ear decompression disease (IEDCS) is likely to occur as a result of the deposition of gas bubbles in the endolymphatic and/or perilymphatic chambers during rapid upward movement by divers (Mitchell & Doolette, 2015; Rozycki et al., 2018). Another possible mechanism of IEDCS is that the patient may also have a right-to-left shunt, showing arterial gas embolism (AGE) as a contributing factor if it enters the labyrinth artery. The classic symptom of the DCS of the inner ear is a sudden attack of vertigo. Tinnitus and acute sensorineural hearing loss can also appear alone or simultaneously (Boyd KL WA, n.d.; Mitchell & Doolette, 2015; Rozycki et al., 2018).

RESEARCH METHOD

This study uses a qualitative approach with a case study model that analyzes and identifies the symptoms that appear in divers suffering from IEDCS.

RESULTS AND DISCUSSION

IEDCS is a not fully understood condition that occurs in divers, likely caused by the deposition of gas bubbles in the endolymphatic and perilymphatic chambers during the rapid process of rising to the surface. The classic symptoms of IEDCS develop in about 30 minutes from the surface and are vestibular; These include vertigo, ataxia (or difficulties with coordination), nausea, and vomiting (Tremolizzo et al., 2015).

Epidemiology

Decompression disease of the inner ear is extremely rare. Although the total number and frequency of IEDCS in divers are unknown, one source reported the incidence of IEDCS in recreational divers using compressed air accounted for nearly 3% of all treated DCS cases (Smerz, 2007). Other sources reported incidents of 0.2 to 0.3% per recreational dive (Lechner et al., 2018). The number of DCS occurrences depends on the dive population (SATOH et al., 1992).

About a quarter of recreational divers who experience neurological decompression disease will have vestibular-cochlear involvement (Arieli, 2019). *Right-to-left shunts* were also found in 81% of patients diagnosed with inner ear DCS compared to 25% of patients who had never experienced DCI. This may indicate an increased risk of DCS of the inner ear in patients with *venous-arterial shunts*(Gempp & Louge, 2013).

Etiology

In general, decompression disease (DCS) is thought to be caused by the formation of gas bubbles inside blood vessels and organ tissues. This is due to the diver inhaling compressed gas when subjected to the high pressure during the dive. This process results in the supersaturation of nitrogen in the circulatory system because the increase in ambient pressure and compressed gas occurs simultaneously according to Boyle's law (Guenzani et al., 2016; Vann et al., 2011). These dissolved gases ventilate out of the body in a proper decompression process (slow ascent to gradually reduce the surrounding atmospheric pressure and release high concentrations of nitrogen through the lungs without significant incident). DCS is charged when excess dissolved gas undergoes rapid pressure changes and triggers the formation of gas bubbles in the blood and tissues, causing obstruction and inflammation. This occurs during the process of rising to the surface when the ambient pressure decreases too quickly to retain the gas solution and expel it through respiration (Guenzani et al., 2016).

IEDCS is usually found on deep dives with the use of helium-oxygen mixtures, especially when breathing gases are diverted from nitrogen-containing decompression mixtures back to helium-containing mixtures (e.g., base mixtures on divers). This is most common in technical/professional divers but can also occur on dives within recreational divers (Guenzani et al., 2016; Vann et al., 2011). Although the actual mechanism is poorly understood, it is thought to occur because helium has a much higher diffusion rate than nitrogen, the diffusion of helium into endolymph-like tissues that are already close to supersaturation results in the formation of bubbles even at the time of the cessation of decompression where the ambient pressure remains constant. This phenomenon is known as isobaric counter-diffusion. Changes in breathing gases should be carefully planned to avoid such effects and avoid changes in diluents when the tissues approach supersaturation. All dives must implement an appropriate decompression stop to minimize such risk (Guenzani et al., 2016; Lindfors et al., 2021).

Risk Factors

In Indonesia, DCS is often experienced by diver fishermen in meeting their living needs. But it does not rule out the possibility that this could happen to other divers, including recreational divers. Lack of knowledge and dives that do not comply with safety protocols will increase the risk of DCS occurring. Other factors that will affect the risk level of DCS occurrence include diving frequency, diving duration, service life, how to rise to the surface, and rest time (Rahmadayanti et al., 2017; Wijaya et al., 2018).

Pathophysiology

The pathophysiology of inner ear decompression disease (IEDCS) is still not fully understood. As described above, the common causes of IEDCS are similar to the causes of DCS in other organ systems (Boyd KL WA, n.d.). The mechanism thought to underlie this is the occurrence of gas precipitation into the endolymphatic system when compared to that into the joint space or more general circulation. Some of the factors that also influence this include inadequate decompression, deep dives that would otherwise require a stop to decompression, and insufficient surface time to rebalance nitrogen (Boyd KL WA, n.d.; Mitchell & Doolette, 2015). Immersion, exercise, and warm temperatures are important factors that can increase the risk of DCS by increasing the absorption of inert gases when under pressure. On the contrary, it is also the same factor that can increase the elimination of inert gases during decompression.

In addition to these factors, the report also indicates the existence of an IEDCS relationship with persistent oval foramen (PFO), a type of *right-to-left shunt* (RLS) (Hartig et al., 2020; Mitchell & Doolette, 2015). RLS allows blood to pass through the pulmonary system. In other words, the gas bubbles that form in the venous circulation are not excreted by the lungs and can enter the arterial circulation or rather referred to as arterial gas

embolism (AGE) (Gempp & Louge, 2013a; Hartig et al., 2020). One study found in 77% of IEDCS cases, large RLS was detected with greater right-side lateralization (80%). But this is also not fully understood. If IEDCS is caused by AGE, it is necessary to carefully observe this phenomenon. IEDCS is also often found in the absence of other brain symptoms (Gempp & Louge, 2013a).

Management

Understanding the metabolism of aspirin in patients with DCS and IEDCS should be carried out immediately with hyperbaric oxygen therapy (recompression therapy) which is the treatment of choice. This action will increase the ambient pressure to push the gas back into the solution and improve oxygen delivery to the ischemic tissue. Controlled decompression will support the process of regulating dissolved gases to prevent the re-formation of air bubbles. After the patient improves clinically, the patient is slowly decompressed to the pressure of the atmospheric surface. Several sessions of recompression therapy may be required if symptoms return (Bove, 2014; Boyd KL WA, n.d.). If recompression therapy cannot be administered immediately, the patient should be given 100% oxygen for several hours (even if there is a resolution of symptoms or not) or until recompression can be carried out. This will trigger *an oxygen washout*, which is when there is a maximum inert gas gradient between the lungs and dissolved gas which results in rapid discharge (Boyd KL WA, n.d.; Vann et al., 2011).

Another early intervention for IEDCS that must be carried out is the resuscitation of adequate liquids with crystalloid solutions. The formation of free gas in the bloodstream can also induce platelet activation, so it can be considered the administration of antiplatelet therapy (aspirin) if needed (Bove, 2014; Klingmann, 2004). In patients with suspected suffering from IEDCS, inner ear barotrauma cannot be easily eliminated. Therefore, bilateral myringotomy should be considered before starting hyperbaric oxygen therapy (Livingstone et al., 2017; Rozycki et al., 2018). But empirically, recompression therapy does not harm if the diagnosis of barotrauma or IEDCS has not been enforceable (Boyd KL WA, n.d.).

Complications and Prognosis

In general, a thorough recovery of a temporary nature from DCS is quite high, especially with proper treatment. A full recovery, however, is still rare. Studies have reported residual deficits in between 32 and 91% of patients, with 3 out of 5 studies reporting residual deficits in more than 85% of patients (Gempp & Louge, 2013a; Rozycki et al., 2018). Vestibular deficits are more common than cochlear deficits. One of the sources states even with adequate recompression therapy, it is common to have residual deficits in balance and hearing. Complications that can occur after hyperbaric oxygen therapy are rare (Mitchell & Doolette, 2015; Rozycki et al., 2018).

Education and Prevention

With the development of technology today and with the implementation of diving safety protocols, any form of DCS can be prevented and the number of cases can also be reduced. Divers, workers in high-pressure areas, and airmen should know and follow appropriate safety measures. Following the decompression schedule is very important for divers, as the majority of patients experiencing IEDCS are found to violate this schedule. Providing information about DCS through education, counseling, or other media needs to be done for at-risk groups in order knowledge that is relevant and can take precautions (Boyd KL WA, n.d.; IRA T, n.d.).

Collaboration Between Teams

Distinguishing between IEDCS and barotrauma is quite difficult. Accurate reports on dive sites, including dive profiles, the onset of symptoms, unwanted events, or sudden changes in depth or gas mixtures, can all provide clues to distinguish DCS from barotrauma. Therefore input from a fellow divemaster, an EMS personnel, and others in contact with the patient is essential. This patient care may include an interprofessional team including an autologist, audiologist, neurologist, hyperbaric physician, and specially trained (Schwerzmann & Seiler, 2001).

CONCLUSION

Part ear decompression disease often occurs in compressed gas divers. This is due to the deposition of gas bubbles in the endolymphatic and perilymphatic chambers during the process of rising to the surface quickly. Symptoms of classic IEDCS develop in about 30 minutes and are vestibular, these include vertigo, ataxia, nausea, and vomiting. The preferred therapy that can be given to people with DCS and IEDCS is hyperbaric oxygen therapy (recompression therapy) immediately. Complications are rare after hyperbaric oxygen therapy. After therapy and DCS sufferers recover, there will usually still be residual deficits in balance and hearing. Diving according to protocol and providing information about DCS through education, counseling, or other media needs to be done for at-risk groups to create knowledge that is relevant and can take precautions.

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